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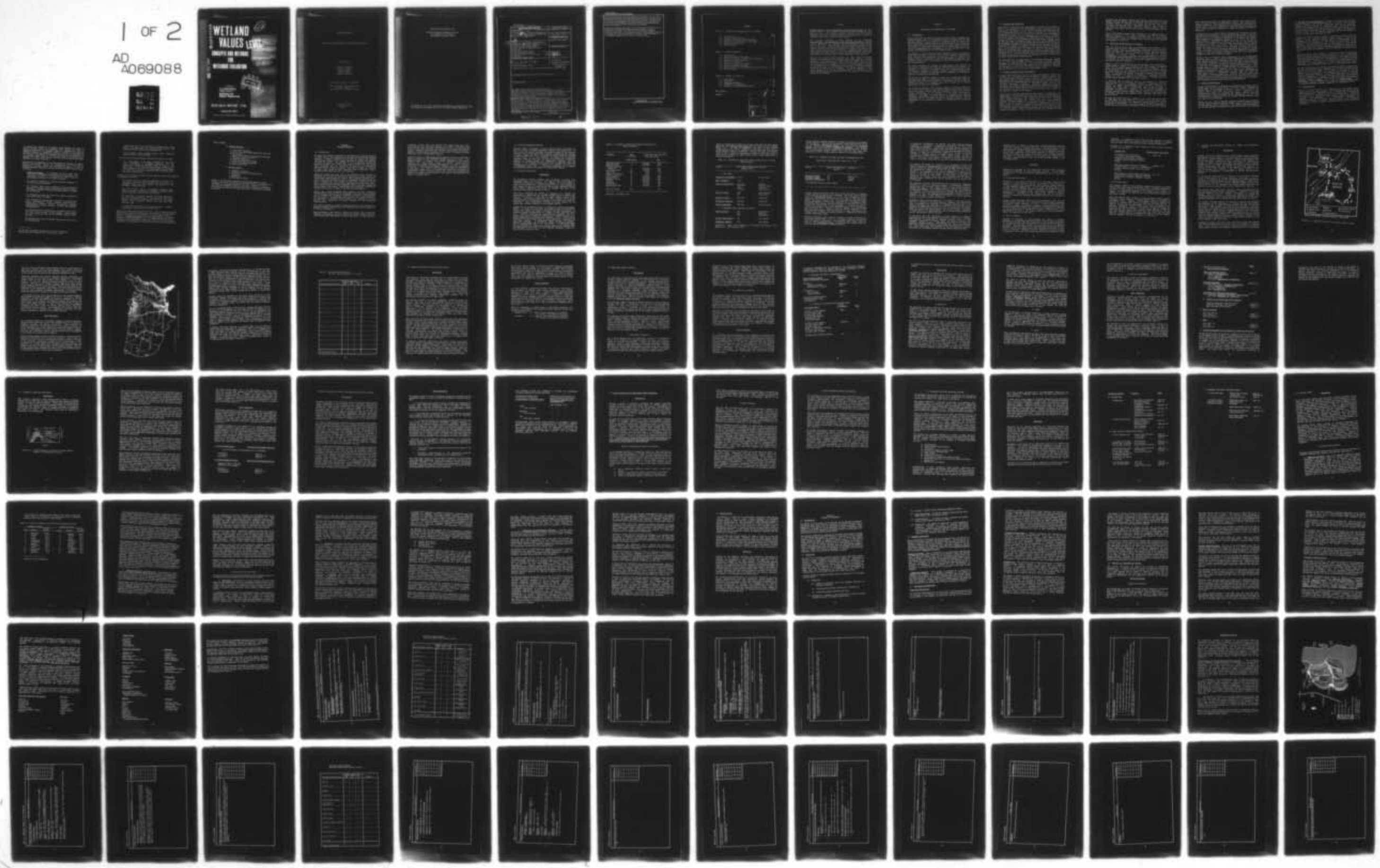

WETLAND VALUES

LEVEL I

CONCEPTS AND METHODS FOR WETLANDS EVALUATION

Prepared by:

United States Army Corps of Engineers
...Serving the Army
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Institute for Water Resources

RESEARCH REPORT 79-R1

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WETLAND VALUES

Concepts and Methods for Wetlands Evaluation

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Report presents concepts and methods for the evaluation of wetlands pursuant to Section 404, PL 92-500 (as amended), President Carter's May 24, 1977 Executive Order on wetlands protection, and other statutory and Administrative authorities. The evaluation of wetlands is based on the analysis of their physical, biological and human use characteristics. The report discusses these functional characteristics and identifies specific criteria for determining the efficiency with which the respective functions are performed.

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Two potential wetlands evaluation methods are described. One is a non-quantitative method in which individual wetland areas are evaluated based on the deductive analysis of their individual functional characteristics. The other is a semi-quantitative method in which the relative values of two or more site alternatives are established through the mathematical rating and summation of their functional relationships.

The specific functions and values of wetlands which are covered in this report are (1) natural biological functions, including food chain productivity and habitat, (2) their use as sanctuaries, refuges or scientific study areas, (3) shoreline protection, (4) groundwater recharge, (5) storage for flood and storm water, (6) water quality improvement, (7) hydrologic support, and (8) various cultural values.

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Chapter 1: Definition and Dimensions of the Problem

Chapter 2: Wetland Evaluation

Chapter 3: Methods of Evaluation

PREFACE

Wetlands Values - Concepts and Methods for Wetlands Evaluation was prepared by the U.S. Army Engineer Institute for Water Resources. This manual is one of many efforts intended to develop a base of technical knowledge pertaining to wetlands and their relationship to the Corps of Engineers' Regulatory and Civil Works programs.

This document represents a major revision of and supersedes *Wetland Values - Interim Assessment and Evaluation Methodology* (Messman et al.), released by the Institute for Water Resources in review draft form in July 1977. This revised report incorporates advances in the state-of-the-art in wetlands evaluation which have taken place in the interim. The Institute for Water Resources coordinated its efforts with other federal agencies which have major responsibilities toward the protection of wetland resources, and to the extent possible this report incorporates the interests and concerns expressed by these agencies.

Three of the authors, Richard Reppert, Dr. Wayne Sigleo and Eugene Stakhiv are currently on the technical staff of the Institute for Water Resources. Larry Messman is a former IWR staff member who left the Institute shortly after release of the 1977 review draft report of which he was senior author. Caldwell D. Meyers is an environmental consultant who contributed to the development and testing of evaluation methods presented in Chapter 3 of the manual. The authors represent a broad cross section of scientific disciplines which are essential to the proper understanding and interpretation of the physical and biological properties of wetlands.

CHAPTER 1

DEFINITION AND DIMENSIONS OF THE PROBLEM

1.1 Introduction

Recent legislation (in particular Section 404, PL 92-500, as amended) and President Carter's May 24, 1977 Executive Order on wetlands have focused national attention on the importance of wetland areas to society and have articulated a national policy concerning their use and protection. Under these authorities and directives, the U.S. Army Corps of Engineers is required to give special consideration to wetland resources in the review of applications for Department of the Army permits, and in the planning and implementation of civil works projects.

Fulfillment of these responsibilities frequently requires the detailed study and evaluation of wetland areas for the purpose of establishing their baseline characteristics and qualities, and for assessing the probable impacts of construction work on the wetlands in question. The purpose of this manual is to assist in providing guidelines for these key determinations.

The manual addresses the problems of identification and evaluation of the physical, biological and human use characteristics of wetlands. In addition to defining and discussing the basic functions and values attributed to wetlands, the manual presents a suggested framework for the practical evaluation of wetlands and the assessment of environmental impacts of engineering alternatives.

The manual is primarily intended to serve as an operational guide for wetland studies made in conjunction with Corps of Engineers regulatory functions and civil works activities. The authors also feel that the manual can serve as a reference work and training aid in wetland principles for Corps field employees.

The manual is limited to the technical aspects of wetland evaluation, and on this basis does not specifically address other public interest factors or policy matters which are involved in either the review of permit applications or the planning of civil works activities in wetlands. The manual is considered to be consistent with existing statutory authorities, executive orders and administrative policies pertaining to the technical analysis of wetland resources and the assessment of the environmental impacts of engineering work in wetland areas.

1.2 Authority and Objectives

Preparation of this manual was authorized by the Chief of Engineers as one of the elements of the Environmental Action Program which was initiated in the Spring of 1976. At that time the manual was conceived as an operational tool for the Corps to utilize in fulfilling its responsibilities under Section 404 of PL 92-500 and other environmental initiatives pertaining to the management and protection of wetlands. One of the specific requirements in preparation of the manual is that it provide a method for the evaluation of wetlands which is capable of use in both the Corps of Engineers permit and civil works programs. Those who originated the idea for the manual also stressed the belief that it be based upon available scientific knowledge about wetlands and thereby constitute an interim tool capable of filling an immediate technology gap. It was anticipated at the outset that the shelf life of the manual would be relatively short, and that it would be superseded by the growing body of scientific knowledge and the technological tools being developed by the U.S. Fish and Wildlife Service and other agencies who are known to be actively involved in advancing the state of the art in wetlands identification and evaluation.

The responsibility for preparation of the wetlands manual was assigned to the U.S. Army Engineer Institute for Water Resources, Kingman Building, Fort Belvoir, Virginia. At the time the assignment was made in March 1976 the Institute was headed by Colonel Daniel D. Ludwig who was succeeded in July 1976 by LTC William Toskey. Augustine J. Fredrich has been Director of the Institute since February 1977.

1.3 Technical Assistance and Coordination

A great many people and federal agencies participated directly and indirectly in the preparation of this manual. Among the agencies are the Environmental Protection Agency, Fish and Wildlife Service, Soil Conservation Service, Forest Service, National Marine Fisheries Service and Department of Transportation, who provided assistance in the form of reference materials, information concerning agency policies and procedures, and technical guidance. During the developmental stages of the project the National Marine Fisheries Service detailed a person to the Institute for Water Resources to assist directly with sections of the manual of interest to that agency.

Among Corps of Engineers personnel who made special contributions to the preparation of this manual were Brigadier General Kenneth McIntyre, former Deputy Director of Civil Works (presently Division Engineer, South Atlantic Division), who conceived the idea for a technical wetlands evaluation manual, Lt. Colonel John Hill, former Assistant Director of Civil Works for Environmental Programs, and Mr. Curtis Clark, Chief of Regulatory Functions, who provided policy advice and administrative assistance throughout the duration of the project. An ad hoc advisory group of Corps wetland experts and planning and regulatory functions personnel reviewed interim products and assisted in both

technical and procedural aspects with specific contributions by Alex Dolgos, Baltimore District; Calvin Fong, San Francisco District; Richard Macomber, Board of Engineers for Rivers and Harbors; Earl Mills, Galveston District; Rudy Nyc, Jacksonville District; Gary Palesh, St. Paul District; Phillip Pierce and David Shepard, Office, Chief of Engineers; John Weber, New Orleans District; and Fred Weinmann, Seattle District.

Lastly, the authors express their gratitude to the combined effort of some 250 employees of the Corps of Engineers and the Environmental Protection Agency for the important part they played in field testing the evaluation concepts and methods during jointly sponsored wetlands training held in late 1977.

1.4 Definition and Delineation of Wetlands

Over the years a great number of definitions have appeared in the literature describing the term wetland including such areas as marshes, swamps, sloughs, bogs, wet meadows, river overflows, mud flats, natural ponds, and potholes. There is probably no single, generally accepted definition for wetland because of the difficulty of verbally encompassing a continuous transition zone between totally dry and wet environments, where boundaries cannot be easily distinguished, and where a diversity of plant species and wetland communities live under a spectrum of physical conditions.

Common in most of the definitions is that wetlands are wet environments, characterized by hydric or saturated soils which support hydrophytic plant life and animals adapted for life in a wet environment. In its permit regulations (33 CFR 320), the Corps of Engineers defines wetlands as "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas."

In President Carter's Executive Order on the Protection of Wetlands issued on May 24, 1977, wetlands are defined as "those areas that are inundated by surface or groundwater with a frequency sufficient to support and under normal circumstances does or would support a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands generally includes swamps, marshes, bogs and similar areas such as sloughs, potholes, wet meadows, river overlows, mud flats, and natural ponds."

The Fish and Wildlife Service (Cowardin et al., 1977) defines wetlands as "land where the water table is at, near or above the surface long enough each year to promote the formation of hydric soils and to support the growth of hydrophytes. In certain types of wetlands, vegetation is lacking and soils are poorly developed or absent as a result of frequent

and drastic fluctuations of surface-water levels, wave action, water flows, turbidity or high concentrations of salts or other substances in the water substrate. Such wetlands can be recognized by the presence of surface water or saturated substrate at some time during each year and their location within, or adjacent to, vegetated wetlands or deep-water habitats."

Cowardin et al., are quite explicit concerning the delineation of upper and lower wetland boundaries. These authors define the upper limit of a wetland as (1) the change from predominantly hydrophytic to predominantly mesophytic or xerophytic vegetation; (2) the change from predominantly hydric to predominantly non-hydric soils, or, in the case of wetlands without vegetation or hydric soils; and (3) the change from land that is flooded or saturated some time during years of normal precipitation to land that is not. The lower limit of wetlands in marine and estuarine systems is the elevation of extreme low spring tides. The lower limit in riverine, lacustrine and palustrine systems is set at a depth of two meters below low water; however, if emergents, shrubs, or trees grow beyond this depth at any time, their deep water boundary is taken as the wetland boundary.

Neither Corps of Engineers permit regulations nor the aforementioned executive order set forth criteria, beyond those which are implicit in their respective wetland definitions, for delineation of the upper and lower wetland boundaries. Delineation of the upper boundary presents the greatest operational problems for the Corps because there is rarely a sharp line of demarkation between wetland and upland sites. Most wetland areas are bounded by a transition zone in which aquatic or semi-aquatic characteristics gradually give way to the mesophytic or xerophytic conditions of upland areas. In many cases, this transition takes place over a considerable distance. Both the Corps and Environmental Protection Agency have currently initiated research into the nature of the transition zone which in the future will be used to develop criteria for the delineation of wetlands which are in accordance with statutory authorities and administrative objectives.

1.5 Wetland Classification

Several classifications of wetlands have evolved and are widely used in various parts of the United States. The more notable classification systems have been developed by Martin, et al., (1953), Stewart and Kantrud (1971), and Golet and Larson (1974). Recently, a new classification system for wetlands and aquatic habitats has been developed by the Fish and Wildlife Service (Cowardin et al., 1977) and is being used in conjunction with the national wetland inventory which that agency now has underway.

Martin, et al., (1953) classified wetlands nationwide based primarily on water depths during the growing season, degree of seasonal flooding and the dominant form of vegetation. This system became recognized as the national standard for wetland classification and was later published

in Wetlands of the United States, Circular 39 of the U.S. Fish and Wildlife Service by Shaw and Fredine (1956). Circular 39 was oriented towards waterfowl, but it has nonetheless been one of the basic references on wetland resources. Although Circular 39 has received wide use, it has recently been criticized for being too general in its classification of wetlands; for the inability to apply the classification to certain local or regional situations, and for its failure to account for many other important functions.

Stewart and Kantrud (1971) provided a classification system which is specific to the glaciated prairie pothole region. This system recognizes seven classes of wetlands which are distinguished by the vegetational zone occurring in the central or deeper part of the potholes. Five subclasses are based on differences in plant species composition which are correlated with salinity gradations of the surface water. Four cover types are also recognized representing differences in the spacial relation of emergent cover to open water or exposed bottom soil.

Golet and Larson (1974) developed a detailed wetland classification system for the glaciated northeast, primarily as a tool for evaluating various freshwater wetlands as wildlife habitat. This scheme describes eight wetland classes which are synonymous with the freshwater wetland types described in Circular 39. In addition the system delineates 24 subclasses, five size categories, six site types, eight cover types, three vegetative interspersion types and six surrounding habitat types.

The new classification of wetlands and deep-water habitats developed by the Fish and Wildlife Service supersedes the Circular 39 classification system at the national level. This system is a hierarchial one and permits the more systematic and universal classification of wetlands than was previously possible. The classification system is structured around a combination of ecologic, biologic, hydrologic and geomorphologic characteristics, proceeding in hierarchial order from system to subsystem, class, subclass, and finally to dominance types. The classification scheme recognizes five principal wetland systems, namely the marine, estuarine, riverine, lacustrine and palustrine systems.

1.6 Wetland Values

One of the initial tasks in the preparation of this manual was to compile a more or less universal list of wetland functions and values which could provide a framework for both the evaluation of wetlands and the assessment of engineering impacts in wetland areas. References utilized in this compilation were relevant federal legislation; an executive order pertaining to the preservation of wetlands; the documented policies of various federal agencies with regulatory, planning and resource management responsibilities; and the scientific literature.

In scoping the contents of the manual, heavy emphasis was placed on source materials which are considered most relevant to Corps of Engineers authorities and programs, namely (1) administrative policies developed persuant to regulatory authority conveyed to the Corps in Section 404 of the Federal Water Pollution Control Act, as amended[1], and (2) President Carter's May 24, 1977 Executive Order on the protection of wetlands (EO 11990) which applies to civil works activities and other aspects of the Corps' program.

Applications for Department of the Army permits are subject to a public interest review which involves the consideration of a broad set of engineering, economic, social and environmental factors. Corps of Engineers general regulatory policies (Section 320.4(b)) state in part as follows:

> "<u>Effect on Wetlands.</u> (1) Wetlands are vital areas that constitute a productive and valuable public resource , the unnecessary alteration or destruction of which should be discouraged as contrary to the public interest.
>
> (2) Wetlands considered to perform functions important to the public interest include:
>
> (i) Wetlands which serve important natural biological functions, including food chain production, general habitat, and nesting, spawning, rearing and resting sites for aquatic or land species;
>
> (ii) Wetlands set aside for study of the aquatic environment or as sanctuaries or refuges;
>
> (iii) Wetlands the destruction or alteration of which would affect detrimentally natural drainage characteristics, sedimentation patterns, salinity distribution, flushing characteristics, current patterns, or other environmental characteristics;
>
> (iv) Wetlands which are significant in shielding other areas from wave action, erosion, or storm damage. Such wetlands are often associated with barrier beaches, islands, reefs and bars;
>
> (v) Wetlands which serve as valuable storage areas for storm and flood waters;

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[1] 33 CFR 320: Regulatory Program of the Corps of Engineers (Federal Register, Volume 42, No. 138, July 19, 1977).

(vi) Wetlands which are prime natural recharge areas. Prime natural recharge areas are locations where surface and ground water are directly interconnected; and

(vii) Wetlands which through natural water filtration processes serve to purify water."

Section 2(a) of Executive Order 11990 states in part as follows:

". . .each agency, to the extent permitted by law, shall avoid undertaking or providing assistance for new construction located in wetlands unless the head of the agency finds (1) that there is no practicable alternative to such construction, and (2) that the proposed action includes all practicable measures to minimize harm to wetlands which may result from such use."

Section 4 of the executive order cites the specific values and qualities of wetlands as follows:

"In carrying out the activities described in Section 1 of this Order, each agency shall consider factors relevant to a proposal's effect on the survival and quality of the wetlands. Among these are:

(a) public health, safety, and welfare, including water supply, quality, recharge and discharge; pollution; flood and storm hazards; and sediment and erosion;

(b) maintenance of natural systems, including conservation and long term productivity of existing flora and fauna, species and habitat diversity and stability, hydrologic utility, fish, wildlife, timber, and food and fiber resources; and

(c) other uses of wetlands in the public interest, including recreational, scientific, and cultural uses."

Based on the above policies and directives, a list of important wetland characteristics has been synthesized for consideration in this manual. These characteristics are divided into two main catagories which include: 1) primary functions; and 2) cultural values. The primary functions closely correspond to the list of wetland characteristics contained in the Corps permit regulations, while the cultural values incorporate socio-economic and other socially perceived considerations.

These include:

1) <u>Primary Functions</u>

a. Food Chain Production
b. General and Specialized Habitat for Land and Aquatic Species
c. Aquatic Study Areas, Sanctuaries and Refuges
d. Hydrologic Support Function
e. Shoreline Protection
f. Storm and Flood Water Storage
g. Natural Groundwater Recharge
h. Water Purification

2) <u>Cultural Values</u>

a. Commercial Fisheries
b. Renewable Resources and Agriculture
c. Recreation
d. Aesthetics
e. Other Special Values

Chapter 2 of this manual presents a general description of these functions and values, and provides semi-quantitative techniques for the assessment of individual evaluation criteria. Chapter 3, in turn, describes two framework methods for the overall evaluation of wetlands and demonstrates their use through application to hypothetical wetland situations.

CHAPTER 2
WETLAND EVALUATION

2.1 Introduction

For years the scientific evaluation of wetlands has been based primarily on their role in the production and utilization of fish and wildlife resources. However, research over the past two decades has revealed that wetlands provide a far broader spectrum of natural and physical functions to society. For example, it is now known that marine and estuarine wetlands with their high primary productivity and energy export potential are the foundation of many of our economically important coastal fishery resources. Wetlands are noted for a variety of cash crops, among the most important being cranberries, timber, furbearers, and other food and fiber resources.

Vegetated wetlands have also come to be valued for their capacity to dissipate the erosive and potentially destructive energy of wave and storm surges along beaches and coasts. Many freshwater wetlands have a natural flood storage capacity, serve as groundwater recharge areas, and tend to moderate the flow regimes of associated streams and rivers. Lastly, wetlands have acquired great importance in recent years due to their limited capacity to remove suspended solids from water, absorb and recycle mineral and organic constituents, and otherwise contribute to improved water quality in many of the nation's watercourses.

Despite more recent knowledge about wetlands and their functional characteristics, research has not progressed to the point where wetlands can be categorically evaluated according to physical classification, type or location. At the present time, the best that can be achieved is an evaluation of wetlands based primarily on individual, or site specific data identified by careful analysis of the functional characteristics.

This chapter provides a synthetic biophysical base for the evaluation of wetlands through consideration of the functions and values referred to at the end of Chapter 1.

These encompass a wide range of evaluative factors, and by necessity represent a combination of both natural and cultural values which are either analytically determined or socially perceived. In most cases the

evaluative criteria have been derived from simple cause and effect relationships, and primarily emphasize the relative efficiency with which the functions and values are carried out in a particular wetland system. Generally, evaluation only requires consideration of empirical, mappable relations easily determined in the field, or otherwise obtained from local, state and government agencies.

Wherever possible, a simple quantitative approach is used to establish a numerical rating for the individual wetland function or value. This system attempts to integrate the relative importance of the various criteria over the entire range of wetland characteristics. Quantitatively, wetland functions determined to be high in relative efficiency or importance are assigned a numerical rating of 3; moderate, 2; and low, 1. If a specific function or value cannot be identified in a particular wetland, then a "not applicable" (N/A) can be entered into the analysis. Thus, the overall quality of a wetland can be assessed by summing the numerical values given to each factor and dividing by the number of component parts.

2.2 Natural Biological Functions

Wetlands, whether freshwater or saline, provide unique environments in which a variety of natural biological functions are carried out. In many cases, the aquatic ecosystem is extremely productive and supports numerous, complex food chains which represent valuable sources of energy to plants, animals and man. In addition to energy production, wetlands provide habitat for a wide diversity of aquatic and terrestrial organisms. Many of these areas are also vitally important as spawning, nursery and feeding ground for economically important fish and shellfish. Since wetlands provide the basis for so many food chains and habitats, it is convenient to separate the discussion of these two interdependent values into: 1) food chain production; and 2) general and specialized habitat for aquatic and terrestrial species.

1) Food Chain Production

Description

All biological activity involves the utilization of energy that ultimately comes from the sun. The ways in which this energy is transferred through the ecosystem are a measure of its efficiency in terms of food production. Primary productivity is a basic measure of this energy flow and is defined as the rate at which producers (chiefly green plants) assimilate the energy of sunlight and store it as potential food resources (Ricklefs, 1973).

This factor determines the growth of vegetation in a habitat and influences the populations and secondary productivity of animals that feed on the plants, or that feed at higher trophic levels in the community. Net primary productivity is then a measure of the stored food potential of the vegetation in excess of that used by the plants in metabolism. This determination provides an overall measure of the energy input directly available to the consumer species.

Productivity is an important factor in evaluating a wetland environment. However, it should be noted that the possible range of productivity values, both within and between particular wetland environments, is extremely variable and dependent on a number of local conditions (Table 2-1). Regional variations are environmentally dependent, and in a general way, reflect latitudinal differences in incident radiation, mean annual temperature and precipitation (Whittaker, 1970). In the case of estuaries, the total energy input of primary production originates from three main sources: 1) macrophytes (marsh grasses, sea grasses, mangroves, macroalgae, and terrestrial plants); 2) benthic microalgae; and 3) phytoplankton (Odum et al., 1972). In evaluating these potential sources, the authors cite several studies which indicate that the macrophytes are by far the most important producers, often by a factor of two or three to one.

Table 2-1 Estimates of Annual Net Primary Productivity of Major Ecosystems

Ecosystem	Area (10^6 km^2)	Productivity per Unit Area gms (dry) m^2/yr Normal Range	Mean
Lake and stream	2	100-1500	500
Swamp and marsh	2	800-4000	2000
Attached algae and estuaries	2	500-4000	2000
Continental shelf	27	200-600	350
Open ocean	332	2-400	125
Desert, rock and ice	24	0-10	3
Tundra and alpine	8	10-400	140
Boreal forest	12	400-2000	800
Temperate forest	18	600-3000	1300
Savanna	15	200-2000	700
Grassland	9	150-1500	500
Desert scrub	18	10-250	70
Agricultural land	14	100-4000	650
Total for earth	510		320

Reference: Whittaker, 1970

Almost all references to annual net primary productivity of marsh plants have dealt with Spartina alterniflora and to a lesser extent, S. patens (Table 2-2). It must be emphasized that much of this data is extrapolated and very little information is available from other wetland areas, whether coastal or freshwater. However, the table is a valuable guide in that it gives the investigator a range of values with which to quantitatively assess and compare productivity in some common types of wetland environments.

Table 2-2. Estimates of Annual Net Primary Productivity of Various Wetland Plants

Species	Net Primary Productivity gms(dry)/m^2/yr	Locality
1. Salt Marsh		
Puccinellia phryganodes	50-140	Arctic Coast
Carex ramenskii	20-40	"
Spartina alterniflora	2000-3000	Georgia
	650-1000	North Carolina
	1500	Virginia
	530-1060	Rhode Island
Spartina patens	1300	North Carolina
	990	Long Island
Spartina foliosa	800-1700	California
Salicornia virginica	650-2500	California
Juncus roemerianus	560-1360	North Carolina
2. Freshwater Marsh (Coastal and Inland)		
Typha latifolia	400	North Dakota
	416	Nebraska
	1350	Long Island
Scripus subterminalis	560	Long Island
Phragmites communis	2700	Long Island

References: Keefe, 1972; MacDonald, 1977; McIntire and Dunston, 1975; Odum et. al., 1972; Reimold, 1977

Another important primary producer in coastal and estuarine environments is the mangrove. The three species present in the United States include the red mangrove (Rhizophora mangle), the black mangrove (Avicennia nitida), and the white mangrove (Leguncularia racemosa). These arboreal species reach their greatest development in southern Florida, although the black mangrove ranges further north into the Gulf coast area. Productivity rates for these trees are shown in the following table.

Table 2-3. Estimates of Annual Leaf Fall from Mangroves as Dry Grams Organic Matter/m^2/year (Odum et al., 1973)

Species	Annual net Production $g/m^2/yr$	Locality
Rhizophora mangle	470[a]	Puerto Rico
Rhizophora mangle	730	Florida
Rhizophora brevistylis	710	Panama

[a] extrapolated from one month's sample

Wetland vegetation provides nutrients to the food chains of numerous consumer species through two main pathways. The first, often referred to as the "grazing food chain," is via the direct consumption of live vegetation by a variety of herbivores (e.g., insects, fish, waterfowl, rabbits and cattle). Odum et al., (1972) indicate that grazing in many wetland environments is practicably negligible due to resistant or other unpalatable plant tissues, and often accounts for less than five percent of the total productivity of the environment. In these situations, a considerable amount of the organic material remains in the environment when the plants die. However, there are specific exeptions to this generalization as geese, ducks and muskrats, to name a few species, are dependent upon a variety of wetland plants for a significant proportion of their nutritional intake.

During decomposition, plant material undergoes a series of physical and biochemical changes which result in a continuous reduction in particle size and change in composition. The remaining organic matter forms the basis of the detrital food chain, representing the largest source of potential energy available to consumer species.

In estuarine environments, the detrital food chain supports numerous organisms by providing a significant proportion of their basic nutritional requirements. Furthermore, the fecal material produced by these species is often included in the food chain of other species, and much of the detritus is organically recycled and subsequently enriched. However, in order for the detrital material to be most efficiently utilized by consumer species of higher trophic levels, it must be exported from the wetland source to larger coastal systems. The rate of export in this type of environment is a measure of the efficiency of the tidal or circulation regime and the location of the wetland source area.

For example, the annual net productivity in irregularly flooded, high marshes dominated by *Spartina patens* and *Juncus romerianus* may sometimes equal or exceed that of the low marsh areas, but most of the detritus is not exported and remains in the form of peat (Odum et al., 1974). Similarly, when considering the role of mangroves in estuarine food chains, it is important to consider the distribution of the different species in relation to tidal regime. In this regard, red mangroves are intertidal or riverine, while the black mangroves tend to grow at somewhat higher elevations and may be affected only by extreme high storm surges.

The discussion of food chain production has to this point emphasized relations in coastal or estuarine systems. Unfortunately, freshwater systems have only received a small fraction of the attention given to coastal environments. This situation does not diminish the importance of freshwater habitats in providing food resources, but rather reflects the intensity of the previous studies and stresses the need for future research. In fact, the freshwater data presented in Tables 2-1 and 2-3 indicate that some of these habitats are equal to or exceed estuarine habitats in terms of primary productivity.

Freshwater plants provide foodstuffs to consumers in the same general ways as do coastal or estuarine species. However, the grazing food chain is probably more important in freshwater habitats than in the coastal environments as many species of waterfowl and fish are strongly dependent on these aquatic plants for food. In the detrital food chain, there are often three major sources of food to the aquatic consumers: 1) marsh detritus; 2) phytoplankton; and 3) detritus from terrestrial sources introduced by upland drainage.

In the first case, the significance of marsh detritus to freshwater ecosystems has not been adequately determined (Keefe, 1972), although this material is undoubtedly an important nutrient source for local consumers, especially in shallow lakes and marshes isolated from organized drainage networks. Phytoplankton may also be an important food source given the relatively high productivity values shown in Table 2-1. Very little data are available on the contribution of detritus introduced into freshwater habitats through natural upland drainage.

Wetlands near or linked to large river systems probably contribute significant amounts of detrital material to a diverse number of food chains as these areas traditionally support large populations of fish and wildlife. Riverine swamp systems can also be important detrital source areas, especially if the organic material is exported into larger systems or directly into coastal or estuarine areas. In these habitats, the amount of exported nutrients to any given area depends on the hydrologic characteristics of the river and the tidal regime of the receiving system.

Evaluation

Evaluating a wetland for its productivity and food chain relations involves consideration of three essential criteria: 1) net primary productivity; 2) mode of detrital transportation; and 3) food chain support.

1) Net Primary Productivity

Estimates of net primary productivity for the major aquatic plant species in a given wetland area may be obtained from a variety of sources, including local universities, state agencies, Federal agencies or other research organizations. In many cases, pertinent data are not available and the evaluator may need to predict the productivity value of the particular wetland under consideration through a detailed comparison of published values from other, relatively similar environments. Alternatively, the evaluator may wish to initiate a program of research to determine productivity values for the wetland in question.

Through either analogous deduction and/or experimental data, the net primary productivity value for a given wetland may be simply classified in terms of "high," moderate," or "low." It must be emphasized that professional judgment is necessary throughout this evaluation process as there are numerous variables and sources of experimental error involved in the determination of productivity values. Quantitatively, areas determined to be high in net primary productivity could be assigned a value of 3; moderate, 2; and low, 1.

2) Mode of Transport

Transport of nutrients in detrital-based food chains is strongly dependent on the hydrologic characteristics of the particular ecosystem. As discussed earlier, the tidal regime and/or wind circulation patterns of coastal and estuarine systems play an important role in detrital transport. Wetlands located in the intertidal zone export more detrital material than do the higher marsh areas infrequently affected by tidal action or overflow. Similarly, detrital transport in riverine systems is dependent on the river flow regime, especially during periods of peak

discharge. By comparison, very little detrital material is exported from isolated lakes and marshes, except during periods of episodic overflow resulting from exceptionally high seasonal precipitation.

Wetlands can be assigned a value relative to their detrital exporting efficiency as follows:

Wetland Type	Relative Export Efficiency
Intertidal marsh; intertidal or riverine, red mangrove swamp; perennial riverine marsh; seasonally flooded riverine swamp and overflow system.	High (3)
Uppertidal marsh; nearly all freshwater wetlands adjacent or linked to intermittently flooded riverine systems, some lacustrine systems.	Moderate (2)
Hydrologically isolated lakes and marshes; inland swamps and bogs; freshwater wetlands adjacent to or linked to ephemeral riverine systems.	Low (1)

3) Food Chain Support

This function refers to the secondary productivity values of consumer species that a particular ecosystem can support. Secondary productivity is then an overall measure of the gross efficiency of the habitat in terms of the nutrients available at the higher trophic levels; for example, it measures how many duck or fish pounds are produced in a particular wetland.

There are numerous ways in which to assess secondary biomass support, including a direct measure of biomass (kg/m^2) and/or its economic or nutritional value. However, no universally accepted standards are provided to evaluate this particular function, and the evaluator is urged to develop his own values based on a careful examination of the pertinent biological and/or socio-economic factors affecting the particular wetland in question. In most cases, specific information concerning the food chain support function can be obtained for the U.S. Fish and Wildlife Service or from state and local fish and game agencies. Wetland habitats determined to be high in food chain support could be assigned a value of 3; moderate, 2; and low, 1.

2) General and Specialized Habitat for Aquatic and Terrestrial Species

Description

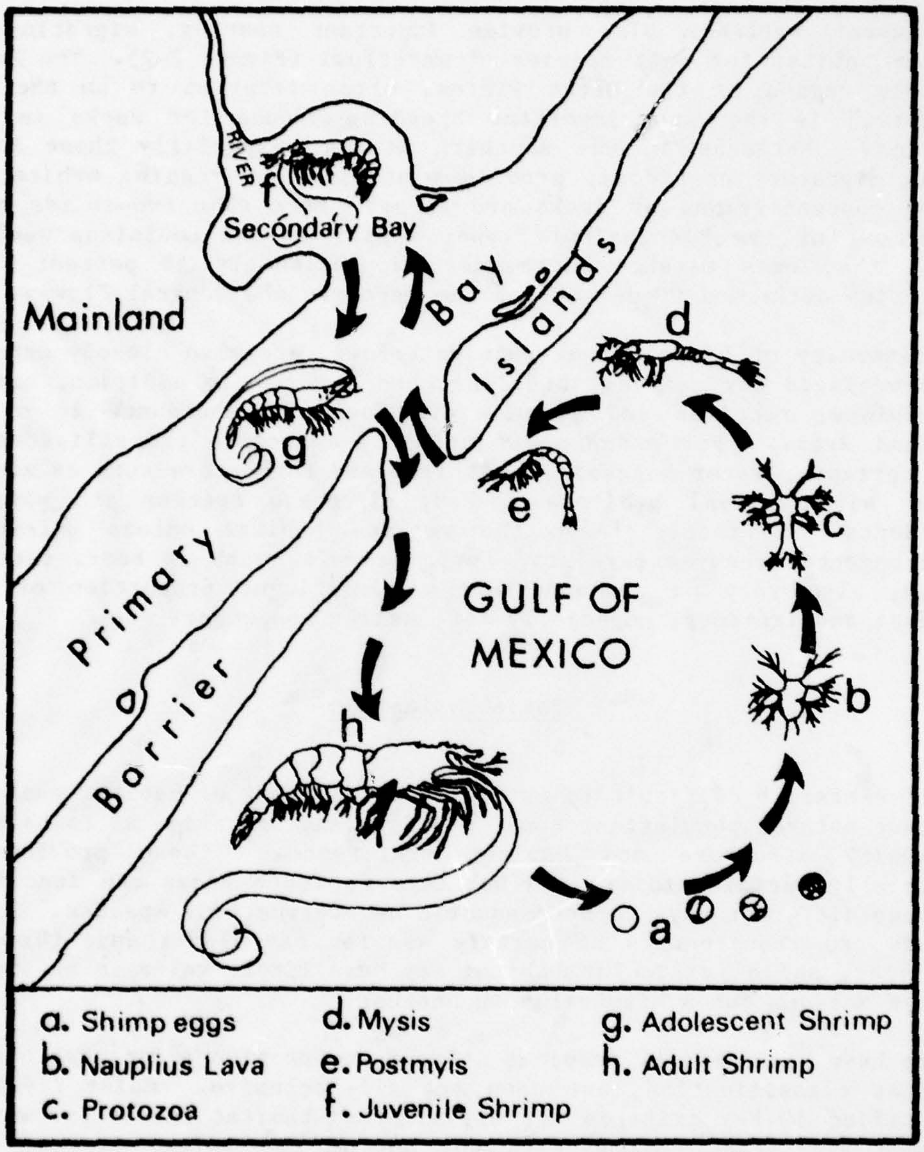
Wetlands occupy the transition zone between aquatic and terrestrial environments, and by virtue of this unique position, provide important habitats for a wide diversity of species. Habitat is generally defined as the place where a particular plant or animal lives. However, the concept of habitat involves more than just locale; it also involves consideration of the ranges and seasonal variations in the environment through evolutionary time, and defines the ecological niche of the organism in the trophic structure of the community. Wetlands act as a type of habitat that fulfills a specific function whether it be propogation, perpetuation, or maintenance of aquatic and terrestrial species.

All species are characterized by a distinct life cycle which is linked to the utilization of one or more habitats. Each stage in the life history of an organism has its own environmental tolerances and habitat requirements upon which survival of the species depends. In some cases, the biological efficiency of a natural community depends solely on the survival of one of its components, and habitat modification affecting the life cycle of one species will directly affect all in some way.

Some species spend their entire lives in a single environment and may have relatively simple habitat requirements. Conversely, others need multiple habitats with more complex requirements to successfully complete their life cycles. Wetlands are important as general and specialized habitat in that these areas often provide both the single or multiple requirements for a disproportionally large number of species.

For example, wetlands adjacent to estuarine or coastal areas normally are essential for the maintenance of various fish and invertebrates which we have come to regard as being estuarine dependent or estuarine associated. Some species, such as white perch and oyster, live their entire lives in estuaries and are closely associated with the particular wetland habitat. Other species, including many oceanic fish and shrimp, utilize these wetlands only for spawning, feeding, cover, or nursery areas for their progeny (Figure 2-1). Anadromous fish species such as shad and alewives migrate through estuarine wetland systems to tidal rivers and their associated wetlands to spawn before returning to the sea to complete their life cycles.

Freshwater wetlands, especially those connected to large river systems, also provide spawning and cover habitat for a large number of non-marine fish. Gunter (1957) noted that most freshwater species only spawn in shallow water, and that the floodplain overflow areas of the Mississippi



Source: A.W. Moffett, The Shrimp Fishery of Texas, 1967

Figure 2-1. Typical Life History of the Gulf of Mexico Shrimp

and other river systems are prime breeding areas for a wide variety of warm water species. Other studies (Sheets, 1977; Bliss, 1977) have indicated that the oxbow lakes and associated wetlands of the Missouri River provide essential nursery and protective habitat for fish.

Freshwater wetlands also provide important nesting, migrating, and winter habitat for most species of waterfowl (Figure 2-2). The Prairie Pothole region of the Great Plains, often referred to as the "duck factory," is the most important breeding ground for ducks in North America. Wetlands in the southern states, especially those located along migratory corridors, provide wintering and resting habitats for large concentrations of ducks and geese. More than two-thirds of the waterfowl of the Mississippi Flyway winter in the Louisiana wetlands, while the Texas marshes accommodate approximately 45 percent of the wintering ducks and 90 percent of the geese in the Central Flyway.

A diversity of birds, other than waterfowl, are also closely dependent upon wetlands for nesting, breeding, and cover. In addition, numerous amphibians, reptiles and mammals are found in abundance in or near wetland areas. For example, we normally associate the alligator, red leg terrapin, water moccasin, bull frog and furbearers such as mink and otter with wetland habitats. Many of these species are permanent residents and rarely leave the wetland habitat unless unfavorable environmental changes persist. Large mammals, such as bear, deer, and moose, also rely on wetlands for a significant proportion of their habitat requirements, especially for feeding and cover.

Basic Evaluation

It is extremely difficult to establish a framework of habitat evaluation because natural populations tend to defy standardization as to behavior, community structure and habitat preference. These problems are especially germaine to wetland habitats as these areas can function in so many different ways to both aquatic and terrestrial species. Habitat values and requirements of certain species can also change throughout the year, and a particular habitat may have little value to an organism in one season, but a high value in another.

There have been several previous attempts to provide a rational basis of habitat classification, but none are all-inclusive. Golet (1973) has identified 10 key criteria for establishing habitat values for wetlands in the glaciated, northeastern portion of the United States. This evaluation is a useful guide for determining wildlife production and diversity, but does not specifically consider aquatic mammals. Shaw and Fredine (1956) provide specific means for delineating wildlife values of various wetland types, although the authors deal with waterfowl and give no information on fish or other aquatic organisms.

Source: U.S. FISH AND WILDLIFE SERVICE

Figure 2-2. Important Waterfowl Breeding and Wintering Habitat

Fortunately, the Fish and Wildlife Coordination Act of 1958 has provided a legal mechanism which provides for the consideration of fish and wildlife values in water resource planning and permitting activity and which specificially requires consultation and coordination with the U.S. Fish and Wildlife Service, National Marine Fisheries Service and the head of the agency responsible for administering the fish and wildlife resources in the affected state. Users of this manual are urged to open up a line of coordination with these agencies as an initial step in determining the habitat value of wetland areas under study. These agencies, particularly the state fish and wildlife management agencies, usually have intimate knowledge of local resources and can provide information as to what species of fish and wildlife utilize project areas and indicate their overall importance as general or specialized habitat.

Wetlands should be evaluated at the local level according to their occasional, seasonal year-around importance as habitat for aquatic and terrestrial species. It is important for the evaluation to identify and consider any specialized habitat relationships which are essential for organisms to complete their life cycle, such as nesting, spawning, resting, feeding, etc.

If it is determined and/or suspected that a wetland area under study is utilized by an endangered or threatened species as defined by the Endangered Species Act of 1973 (P.L. 93-205), it is recommended that this evaluation be terminated and that policy guidance specific to the implementation of Section 7 of the Endangered Species Act be utilized instead. Current policy guidance is contained in Engineer Circular 1105-2-77 which expires on 31 December 1978. Subsequent to that date Corps of Engineers field elements should consult any permanent guidance which is issued on this subject or the Office, Chief of Engineers, ATTN: DAEN-CWP-P.

A habitat evaluation checklist is provided (Table 2-4) to assist in identifying and evaluating any important habitat relationships which exist in wetland areas under consideration. The list is suggested as a guide with which to structure and document inputs relative to habitat characteristics which are derived directly or through the coordination process. In using the table, high habitat significance should be assigned a numerical rating of 3, habitat of moderate value a rating of 2, and habitat of low value a rating of 1.

TABLE 2-4 HABITAT EVALUATION CHECKLIST
(Key game, commercial and aesthetic species)

Fish and Wildlife Species	Habitat Significance			Remarks
	High (3)	Mod. (2)	Low (1)	
Overall Habitat Value				

2.3 Aquatic Study Areas, Sanctuaries and Refuges

Description

Large areas of the nation's wetlands have been traditionally set aside for scientific study and the protection of aquatic and terrestrial habitats. The National Wildlife Refuge System was first enacted in 1903 by Executive Order of President Theodore Roosevelt to establish the Pelican Island Refuge in Florida. Since this time a number of other Federal actions, such as the Migratory Bird Conservation Act of 1929, the Fish and Wildlife Coordination Act of 1934, and the Duck Stamp Act of 1949, have helped to considerably enlarge the refuge and sanctuary system. It is appropriate to give brief consideration to these special aspects of wetlands, particularly where Federal, state, public and private interests have committed substantial resources for the maintenance and preservation of these areas.

The National Registry of Natural Landmarks, authorized under the Historic Sites Act of 1935 and administered by the National Park Service, lists areas which illustrate the diversity of the nation's natural history. The objective of this program is to recognize and preserve significant ecological and geological areas of national importance. To be eligible for the Registry, a site must have exceptional quality or value in illustrating or interpreting the natural heritage and must be an essentially unspoiled example of a natural area. Many wetlands are included on the Registry with still more being nominated for possible future registration.

Many non-profit and other public interest groups have also established private sanctuaries and refuges, some of which encompass large areas of wetlands. Many of these areas serve as research and educational centers oriented towards wildlife observation and nature study for the general public. The National Audubon Society is a prime example of one of these groups and has an ambitious program managing refuges and sactuaries all over the United States. The Nature Conservancy cooperates with colleges, universities, and public and private interest groups to acquire natural areas for scientific and educational purposes. Although most of these centers are located in terrestrial ecosystems, several large wetland areas come under their jurisdiction, including 49,000 acres of the Great Dismal Swamp in Virginia.

In addition, scientific institutions and public interest groups have long given special consideration to wetlands because these environments constitute unique natural laboratories. These areas are not only of interest from the standpoint of their specialized flora and fauna, but also in that they facilitate the study of energy budgets, cycling of nutrients, interspecific relationships and population dynamics. Many more of these areas are being preserved for scientific study as the intensity of research grows and techniques become more sophisticated.

The wildlife habitat value of wetlands has also long been recognized. Many states operate refuges for the purpose of maintaining huntable populations of both migratory and non-migratory wildlife. These refuges may be on public lands, or in some cases, the states develop cooperative arrangements with private landowners to manage the areas in special ways. The white cedar and other forested swamps which serve as winter deer yards are examples of privately-owned and managed refuges in New England and the northern tier states.

Basic Evaluation

It is not possible to arbitrarily assign three levels of importance in the evaluation of wetland study areas, sanctuaries, and refuges. However, all areas that are: 1) legally and/or administratively controlled as such by a public agency or responsible non-profit organization, or 2) included or eligible for inclusion in the National Register of Natural Landmarks should be assigned a high (3) value. All other wetland areas, not included in these categories, must be evaluated individually to determine their own scientific, educational and/or public interest value, and in all cases, professional judgement must be excercised.

While the assignment of lesser values is necessarily subjective, the evaluator could establish the appropriate lower numerical values using the following schedule:

Moderate Value	(2) -	Areas of state importance, not eligible for listing on the National Register.
Low Value	(1) -	Areas of local importance, not eligible for listing on the National Register.

2.4 Hydrologic Support Function

Description

U.S. Army Corps of Engineers permit regulations 33 CFR 320.4 (b)(2)(iii) ascribe a special value to wetlands ". . .the destruction or alteration of which would affect detrimentally natural drainage characteristics, sedimentation patterns, salinity distribution, flushing characteristics, current patterns, or other environmental characteristics." These variables are linked to physically related, hydrologic relationships and together with the natural biological functions define the integrated structure of a wetlands ecosystem. The regulations are clearly concerned with the effects that modification of specific areas could have on the entire wetland ecosystem and on the cumulative effects of piecemeal alteration. Implicit in this relationship is an important wetland function, which for the purposes of this manual will be refered to as the Hydrologic Support Function.

The hydrologic support function is defined as the role which a specific wetland area plays in maintaining the stability and environmental integrity of the entire system to which it is physically and functionally related. Evaluation of this relationship requires an indepth analysis of the manner and extent to which a wetland serves to protect the physical chracteristics of the larger ecosystem to which it belongs.

This function is by far the most difficult to analyze due to the complex of interrelated physical, chemical and biological variables involved in natural systems. Precise quantitative analysis of these variables and their interrelationships usually requires highly sophisticated techniques and instrumentation beyond the scope of most routine water resource planning or permit investigations. However, the importance of the function can be approximated through a basic analysis of the wetland type in terms of its hydrologic periodocity and location or elevation relative to the main aquatic system.

1) Hydrologic Periodocity

For a given wetland type, the hydrologic perodicity or hydroperiod refers to the frequency of inundation either by tides, river flow, or runoff and direct precipitation. Marine and estuarine ecosystems generally have the most thoroughly integreated hydrologic linkages, especially in those areas characterized by strong tidal flow. The ebb and flood of tides in these environments maintains a regular interchange of nutrients, detritus and other essential chemical and organic constituents between the main water body and the adjacent wetland.

Conversely, the poorest linkage between areas within wetland systems and between wetlands and their associated water body exists in hydrologically isolated systems including closed lake basins, potholes, perched wetlands and marshes. These types of environments are not characterized by strongly defined current patterns, except where generated by wind, and the total export of organic and mineral nutrients is relatively low. Non-tidal riverine systems lie between these two extremes with respect to the hydrologic linkages between wetland and the aquatic system. Under natural conditions, perennial river systems are subject to a three-dimensional mixing pattern, and although flooding and drainage of the adjacent wetlands is often seasonal or irregular, the overall interchange of water tends to be large.

2) Location or Elevation

The hydrologic support function can also be evaluated by examining the relationship between the hydrologic regime and specific locational factors of wetlands within their respective ecosystems. This factor defines both the extent and degree of flooding that a particular wetland is subject to, irrespective of the frequency of inundation. The most complete hydrologic and ecological linkages exist in those wetlands which are either flooded to the greatest depth and/or are nearest to the associated open water system, regardless of type or areal extent.

Hydrologic relationships will progressively deteriorate as the depth of flooding decreases, and as the wetland is distributed farther from the open water system. (Gosselink and Turner, 1977) The weakest hydrologic linkages will exist in those areas where wetlands are physically isolated from other areas within the system and the open water body, either by natural or artificial barriers. In wetland systems characterized by uniformly low gradients and not separated from adjacent areas, ground level elevation can be used as an indicator of the depth of flooding and/or proximity to open water.

Basic Evaluation

The evaluative factors pertaining to the hydrologic periodicity and location or elevation of the wetland under consideration are relatively straightforward, and can generally be determined through analyses of local topographic maps, hydrologic data, field observations and other routinely available data. It must be emphasized that each wetland environment is unique in terms of its hydrologic and other physical characteristics, and the above generalizations are only presented as preliminary guidelines for the initial evaluation of a complex functional relationship. In addition, very little research has been conducted on the hydrologic relationships both within and between wetland systems.

A suggested framework for the analyses of the individual variables considered in the hydrologic support function and an assessment of their relative numerical value are presented as follows:

1. Hydrologic Periodicity (hydroperiod)

Type of Wetland System	Frequency of Inundation	Value
Marine or Estuarine Intertidal	High	3
Riverine		
seasonally flooded	Moderate	2
intermittently flooded	Low	1
Lacustrine		
open drainage	Moderate	2
closed drainage	Low	1
Palustrine (hydrologically isolated marshes, bogs and potholes)	Low	1

2. Location or Elevation within Wetland System

Locational Factor	Extent of Flooding	Value
In lake or river systems, from low water level to mean water level. In intertidal wetlands, from mean low tide to mean high tide.	High	3
In lake & river systems, from mean water level to upper limit of marsh. In intertidal wetlands, from mean tide water to upper limit of marsh.	moderate	2
Hydrologically isolated systems	Low	1

2.5 Shoreline Protection (Shielding from Wave Action, Erosion or Storm Damage)

Description

Wetlands can function to dissipate the energy of wave attack and storm surges, and thus lessen the effects of erosion. This function is particularly important in marine or estuarine areas, although depending on the local situation, a significant degree of shoreline protection can be ascribed to wetlands fringing larger lakes and riverine environments. Wave action shielding by wetlands is not only important in preserving natural shorelines and channels, but also in protecting valuable residential, commercial and industrial areas located adjacent to the aquatic systems.

In many cases, wetland vegetation effectively reduces wave energy to preclude or moderate storm damage and prevents shoreline erosion through bank stabilization. The value of a wetland in wave dissipation and shoreline stabilization involves consideration of the following variables: 1) vegetation characteristics; 2) width; 3) fetch and local bathymetry; and 4) adjacent cultural development.

1) Vegetation

The importance of coastal vegetation in reducing wave action and storm damage has been demonstrated by Teal and Teal (1969) in a study of the coast of Lincolnshire, England. In 1953 a severe storm in this area resulted in extensive coastal damage and most beaches and shoreline structures were completely destroyed. However, the areas lying landward of salt marshes were protected from the full force of the storm and sustained little damage.

The role that wetland vegetation plays in protecting shorelines from erosion depends primarily on the type, structure and density of the plant community. This conclusion is supported by limited research from energy environments which indicate that wave height and thus energy reduction in coastal areas is species dependent. Wayne (1975) found that Thalassia testudinum, a common submerged marine grass, reduced short period wave heights by as much as 43 percent and wave energy by about 66 percent. The subaerial height of wetland species is also an important factor in dissipation wave energy. Intertidal marsh species, such as Spartina alterniflora, increase surface roughness over the marsh area by their height and stem rigidity. In support of this conclusion, Wayne found that this species reduced wave height by as much as 71 percent and wave energy up to 92 percent in the Gulf Coast study. By analogous deduction, the density of the plant community is also an important factor in retarding erosion since a high density of plants would tend to increase the surface roughness coefficient of the marsh area. Wetland

vegetation decreases the potential for soil erosion by binding the substrate through root or rhizome systems. The efficiency of vegetation in groundsurface stabilization through root or rhizome systems appears to be a function of the plant species and its density over the marsh. In this regard, herbaceous wetland species, such as Spartina spp., tend to retard erosion through the development of dense stands of plants with fibrous root systems (Woodhouse et al., 1964).

The value of wetland grasses in soil and shoreline stabilization programs has long been recognized by both the U.S. Army Corps of Engineers Waterways Experiment Station and the Coastal Engineering Research Center. Both of these agencies have conducted and sponsored research for the establishment of marsh grasses for erosion control in coastal areas, especially on dredged material.

The importance of subtropical, wetland arboreal species in reducing soil erosion has also been emphasized by Scoffin (1970) in a study of shallow water, carbonate sedimentation in the Bahamas. Scoffin found that dense mangrove (Rhizophora mangle) swamps with their complex root systems trapped more sediment at a higher rate than did comparable areas without mangroves. Mangroves and other arboreal species may be more important in preventing erosion than are marsh grasses as their greater height and root system offer greater resistance to wave passage, but trees and shrubs cannot prevent damage due to flooding.

2) Width

The effectiveness of wetland vegetation to abate shoreline erosion depends in part on the width of the vegetated area and its buffering effect in reducing wave energy (Garbisch et al., 1975). In general, a simple intuitive relationship can be established: the wider the area of wetland, the greater the potential for shoreline protection afforded. However, it must be emphasized that this factor is extremely variable, and as a criterion, width should be related to specific vegetation types and the associated wave or current environment which affect the wetland in question.

3) Fetch

Fetch is defined as the distance at which wind can be directed unimpeded across an open body of water. The amount of wave action along a given shoreline is directly related to the magnitude of fetch since wind blowing across a long fetch drives higher volumes of water with more potential erosive energy than a short fetch. Thus, a wetland in an area of high fetch affords more shoreline protection than does a similar wetland in an area of low fetch.

For the purposes of this manual a long fetch is considered to be greater than 5 miles in length and is assigned a numerical value of 3. A fetch of moderate length is considered to range between 1 to 5 miles and is assigned a value of 2, whereas a short fetch is less than 1 mile and is given a value of 1.

4) Cultural Development

The value of a wetland in terms of protecting residential, commercial and industrial areas adjacent to coasts depends primarily on the density of population, the type of development and its capital value. In addition to these criteria, consideration must be given to the degree of shoreline protection that particular wetlands afford to sparsely populated coastal regions. However, the value of a wetland in shoreline protection generally increases in relation to the degree of cultural development adjacent to the coast or river channel.

Basic Evaluation

Evaluation of these variables is relatively straightforward and the vegetation characteristics, width, fetch and degree of cultural development can be determined from a number of local sources. The floristic composition and structure of the wetland vegetation may be obtained by one-site inspection or from a variety of sources including local universities, state or Federal agencies or other research organizations. Plant density may be estimated directly from aerial photographs or measured in the field using various transect or quadrat methods of vegetation mapping (Kuchler, 1967). Shoreline morphology and data on related wave or current environments can be obtained from bathymetric, hydrologic and topographic maps, or where information gaps exist, from a variety of local sources including experts in Corps division and division offices. Data concerning the population and economic structure of areas adjacent to the wetlands under consideration may be obtained from the appropriate state or Federal agencies.

The following criteria are suggested for the preliminary analysis of a wetland for its potential shoreline protection value. It must be further emphasized that these criteria represent generalizations and each wetland under consideration must be evaluated on a site specific basis. Since only limited research has been conducted on the shoreline protection function of wetlands, the means for evaluation presented below are based primarily on intuitive judgement. The criteria appear to be reasonable and could be used in the interim until more definitive information is available.

	Value
1. Vegetation Characteristics	
A. Type of Wetland Vegetation	
Shrub and Arboreal Species	High (3)
e.g. mangrove (*Rhizophora* sp.)	
willow (*Salix* sp.)	
Alder (*Alnus* sp.)	
Buttonbush (*Cephalanthus occidentalis*)	
Non-woody Emergents	Moderate (2)
e.g. intertidal grasses (*Spartina alterniflora*)	
rushes (*Juncus* sp., *Eleocharis* sp.)	
cat tails (*Typha* sp.)	
reeds (*Phragmites* sp.)	
Submergents and Floating Leaved Species	Low (1)
e.g. seagrasses (*Thalassia testudinum*, *Zostera marina*)	
pond weeds *Potomogeton* sp., *Nuphar* sp.)	
B. Density of the Total Vegetation Community	
Dense (coverage more than 80 percent)	High (3)
Semidense (coverage 50-80 percent)	Moderate (2)
Open (coverage 20-50 percent)	Low (1)
2. Width of Wetland	
More than 200 yds	High (3)
100 to 200 yds	Moderate (2)
Less than 100 yds	Low (1)
3. Fetch	
More than 5 mi	High (3)
1 to 5 mi	Moderate (2)
Less than 1 mi	Low (1)

4. Cultural Development and its Relation to Shoreline Protection.

This particular factor is difficult to assess in specific detail because of the number of socio-economic considerations which could be involved. Hence, the evaluation of the shoreline protection function of wetlands in relation to local residential, commercial or industrial development is largely left to the professional judgement of the field personnel on a specific case-by-case basis. However, some suggest criteria which could be used to evaluate cultural development adjacent to a wetland area include the type and density of development, its population, commercial value, proximity to shoreline and elevation above mean water level. The latter two criteria are particularly important in

establishing the value of the wetland in terms of the degree of shoreline protection afforded to the area of cultural development. In general, the closer the cultural development is to the shoreline, whether estuarine, riverine or lacustrine, the higher the value of shoreline protection provided by the adjacent wetlands. In addition, the greater the lateral extent of the wetland along the coastline, the greater is the potential for reducing wave damage to the adjacent area of cultural development.

2.6 Storage for Storm and Flood Water

Description

Many wetlands, especially those hydrologically linked to riverine systems, may be important for water storage and flow retardation during periods of flood or storm discharge. These areas can significantly reduce or at least modify potentially damaging effects of flood flows by intercepting and retaining water which might otherwise be channelled through open flow systems. Figure 2-4 demonstrates these relationships and shows the effects that wetlands could have in altering a hypothetical flood hydrograph.

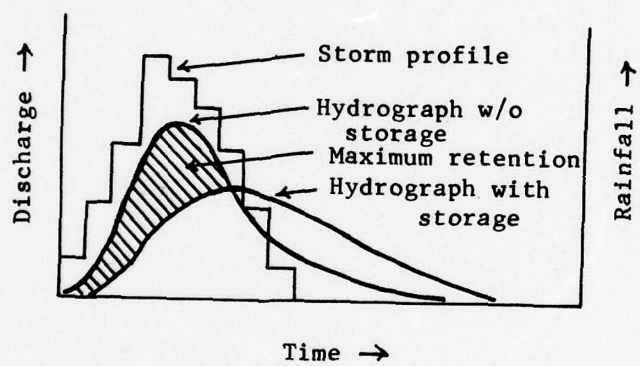


Figure 2-4 Flood hydrograph in relation to wetland storage capacity in an idealized situation

Due to the low gradient of most wetlands, flood or storm water tends to be evenly distributed over the area and move slowly across the surface. As surface runoff occurs when the rainfall intensity exceeds the infiltration rate, the flood storage capacity of a particular wetland is primarily a function of its area, substrate texture and previous degree of saturation. In general, the greater the area and porosity of the wetland substrate, the greater the potential for flood water storage, given unsaturated field conditions.

Wetland vegetation is also important in reducing the energy of flood or storm water. Depending on both the nature and density of the plant cover, the presence of vegetation tends to decrease the velocity of overland flow by increasing the surface roughness over the area of the wetland. This effect is especially important along relatively shallow stream channels or tidal inlets as the vegetation raises the surface level of the wetland and acts to retard flood flows.

It is important to note that very little previous research has been conducted to demonstrate the effects that wetlands have in terms of flood storage and detention. Niering (1966) has briefly emphasized the importance of wetlands in modifying flows during the 1955 episode of severe flooding in eastern Pennsylvania. In this flood, hundreds of bridges were washed out along many of the major river courses. However, two bridges of the same design were left standing in one catchment and both were located immediately downstream of wetland areas preserved by the Nature Conservancy.

The U.S. Army Corps of Engineers' Charles River Watershed project provides a good example of the role that wetlands can play in storing storm and flood water. The watershed encompasses 307 sq. mi. in eastern Massachusetts and contains numerous small freshwater wetlands which total several thousand acres. The lower third of the watershed is occupied by the densely populated and developed Boston-Cambridge urban complex. The middle third is a less heavily populated, suburban area and the upper third is primarily rural in character.

Past hydrologic records consistently demonstrated that extensive flood damage occurred in the lower reaches of the basin, while only relatively minor effects were felt in the upper and middle portions. Since there were no flood control dams in the upper and middle reaches, hydrological studies were initiated by the U.S. Army Corps of Engineers to determine how flood waters were distributed in these portions of the basin. After the 1968 flood investigators found that wetlands in these areas were acting as natural controls to retain flood waters. Storm water was effectively stored in the numerous wetland areas and released so gradually into the main channels of the river that damage was held to a minimum for some distance downstream.

The 1968 interim report led to the authorization of flood control structures in the lower reaches to control high runoff in urban areas where no wetlands existed. However, the study also found that structural alternatives for the upper and middle reaches would add little to enhance the natural flood control benefits provided by the wetlands. Congress in 1974 later authorized the acquisition of 17 more critical wetland areas totaling about 8500 acres in order to preserve their flood control capacity.

Basic Evaluation

Preliminary evaluation of the floodwater storage and flow retardation value of wetlands can be approximated easily using local topographic and geologic maps, hydrologic data, field observation and other routinely available information. As wetland area, substrate and vegetation characteristics vary widely both within and between different catchments, generalizations concerning this particular function are difficult to make and each case must be analyzed and evaluated at the local level.

A suggested framework for the analysis of the floodwater storage and retardation function is given below. In most situations the physical characteristics of the particular wetland or wetland system must be directly compared with the flood damage potential in relation to locally developed areas. In this regard, it is obvious that wetlands of even nominal extent located in highly developed, urbanized catchments could afford significant levels of flood protection. In the case of marine, estuarine or lacustrine systems, wetlands lying seaward of developed areas could be significant in protecting these coastal areas from extreme tidal and/or storm events.

1 Flood Storage Factor	Potential Flood Damage Reduction
Area of Wetlands (As percentage total of watershed)	
>20 percent	High (3)
5-20 percent	Moderate (2)
<5 percent	Low (1)

2 Flood Retardation Factor	Potential Flood Damage Reduction
Vegetative Cover of Wetland (Wooded or Shrub Swamps)	
>30 percent	High (3)
10-30 percent	Moderate (2)
0-10 percent	Low (1)

2.7 Natural Groundwater Recharge (and Associated Hydrologic Effects)

Description

Freshwater wetlands are by definition poorly drained areas which usually occupy depressions on the landscape; their hydrologic relations are largely determined by both the magnitude and frequency of surface water saturation. Many wetland types, such as swamps, wet meadows and riverine-related features, are sustained wholly or in part by groundwater which is at or near the surface for some part of the year. These wetlands are often groundwater discharge or intercept zones during normal or particularly wet periods. During dryer intervals, the storage potential of these wetlands, determined by local soil and geologic conditions, can act as groundwater recharge zones for any underlying or adjacent aquifers.

In contrast, hydrologically isolated wetlands, including some marshes, bogs and lacustrine-related types, are maintained only by standing or running water which accumulates by precipitation or flooding during part of the year. In this regard, wetlands of this type may or may not be linked to a local or regional groundwater system. During periods of below normal precipitation, these wetlands may shrink considerably or even temporarily disappear. The groundwater function of wetlands is primarily related to landsurface features and processes which affect overland flow, interception, infiltration, depression storage, interflow and groundwater flow. In addition, certain physical and morphological characteristics, such as soil type and substrate geometry, strongly influence both the nature and efficiency of the hydrologic linkages between wetlands and associated groundwater systems.

Direct recharge from precipitation and/or by surface water infiltration involves vertical and horizontal movement of groundwater under the influence of gravity. With favorable soil and geological conditions, groundwater recharge directly from a wetland can occur only if the area is linked to an aquifer and the substrate is less than fully saturated. In most cases, permanent wetlands cannot be considered to be prime recharge areas as these wetland types may in fact exist solely as discharge zones throughout most of the year. Alternatively, some wetlands which are only seasonally or intermittently flooded could provide a significant contribution to local groundwater flow, especially during periods of low stream flow. Examples of these types of wetlands include those along or within some coastal areas, glacial drift zones, karst areas, and semi-arid flood plains.

Basic Evaluation

The probable degree to which a particular wetland may contribute to the groundwater regime in a given area may be determined in several indirect ways:

1. By estimating area, depth of soils, porosity and transmissivity of soil types within the wetland from SCS or USGS maps; and depth to bedrock maps relating groundwater flow to known soil types. Determination of the type of soil layers within the groundwater storage area below the wetland is also an important criterion.

2. By attempting to establish pumping rate correlations with water level changes within the wetland as a measure of the hydraulic interaction and relationship to known aquifers.

3. By assessing whether an individual wetland area of small size (1-10 acres) has any perceptible groundwater recharge potential, in relation to all wetlands within a particular watershed. Whereas one isolated wetland area in a wetshed may not significantly contribute to groundwater recharge, when taken together as a natural system, all such wetlands may have a substantial effect on the total groundwater regime. One method in assessing this factor would be to compare the base flow characteristics for several similar watersheds with varying proportions of wetland areas. Theoretically, the lower the flow, the larger the contribution of the wetlands to the groundwater interflow relationship.

Evaluation of the groundwater recharge potential of a particular wetland involves consideration of the physical criteria pertaining to recharge hydraulics. The physical criteria which directly influence the recharge potential are:

a. Total areal extent of wetlands and other static waters in the catchment.

b. Hydrologic characteristics of the associated aquifer(s) including porosity, permeability and transmisability.

The total areal extent of the wetlands in question can be estimated using available topographic and/or photo mosaic map coverage of the particular watershed. The pertinent hydrologic factors influencing groundwater flow and other relationships can be determined and assessed using the appropriate geologic reference materials or by consulting with area hydrologists familiar with local conditions.

The following criteria are suggested to evaluate the groundwater recharge potential of a particular area:

Groundwater Recharge Area (areal extent of wetlands as percentage of total watershed)	Hydrologic Characteristics of Wetland Substrate and Aquifer (porosity, permeability and transmisability)		
	High	Moderate	Low
High:			
over 5 percent	3	2	1
Moderate:			
2 to 4 percent	2	1	-
Low:			
less than 2 percent	1	-	-

Socio-economic factors which relate directly to groundwater recharge potential and supply should be determined at the local level in order to assess the importance of the wetland resource. Factors pertaining to the present and projected needs for municipal, industrial and agricultural water requirements can be obtained from a variety of government agencies, state geological surveys, local and regional planning authorities.

2.8 Water Purification through Natural Water Filtration

Description

Through a variety of physical, biological and chemical processes, wetlands function to naturally purify water by removing organic and mineral particulate matter from rivers and streams. Wetlands may be significant in minimizing some of the harmful effects of pollutants introduced into natural ecological systems by the activities of man. Thus, the presence of wetlands, especially those part of riverine or estuarine systems, can be an integral part of water quality and pollution control objectives.

In terms of the natural water purification and waste removal function, wetlands are somewhat analogous to sewage and wastewater treatment plants. A treatment plant is essentially a unitized and sequential water purification system which incorporates many of the natural processes that occur in wetlands, including primary and secondary waste removal. However, major differences exist between the water purification processes in a waste treatment plant and those which occur in wetland systems. In the first place, it is important to note that the rates of purification and waste removal in a treatment plant are greatly accelerated due to the application of man-induced physical and chemical processes. A second, and perhaps more important difference, is that the main result of natural water purification in wetlands is the recycling of pollutants, while the primary goal of a waste treatment plant is the actual removal of waste material.

Nature of Wetland Water Quality Improvement

It is somewhat difficult to generalize about the water purification function of wetlands because of the wide diversity of wetland types and their individual characteristics. There are also numerous problems in determining the net efficiency at which a particular wetland can recycle pollutants, its BOD loading tolerance, and the long-term effects on the ecosystem. However, basic analyses of the processes involved in the natural water purification value of streams and wetlands require consideration of those physical, biological and chemical characteristics which:

a) aid in mechanical dispersion and/or removal of particulate matter;
b) enhance or contribute to physical adsorbtion of pollutants;
c) promote chemical precipitation and/or ion exchange; and
d) result in biochemical uptake, assimilation and systhesis.

Three types of evaluative criteria are considered here to encompass some of the key environmental conditions which may be relevant to the wetland function of water quality improvement. These include consideration of the wetland type, its areal extent and geographic factors of its location.

1) Type of Wetland

Both the type of wetland and nature of the vegetation community are important factors in estimating the rate and efficiency of decomposition, assimilation and systhesis of pollutants by the ecosystem trophic structure. The daily, seasonal and annual rate at which water, with its pollution load, flows through a particular wetland system largely determines the nature of the water quality improvement function. This factor, related to the hydroperiod, is a rough measure of the potential of the wetland to assimilate the waste load and distribute the recycled nutrients to a larger part of the ecosystem.

Marine or estuarine wetlands, subject to either diurnal or semi-diurnal hydroperiods, have certain advantages over those of riverine systems due to the regular exposure of bottom materials to aerobic decomposition processes. Conversely, hydrologically isolated lakes and ponds tend to act as storage reservoirs for wastes as their flushing characteristics are more dependent on wind mixing and changes in thermal stratification. Seasonally inundated bogs, swamps and potholes have very specialized degradation processes which pertain mainly to the organic, acid-forming stages of anaerobic decomposition. Although the breakdown of organic products, and therefore the waste treatment potential, is proportionally increased in these types of wetlands, the rate of decomposition is extremely slow. This factor is primarily due to the proportionally smaller volume of water with restricted transport and transfer of the decomposition products.

A second characteristic of the wetland type is the nature and density of the plant cover. Vegetation type and density directly affect the initial processes of mechanical, biological and chemical removal of particulate matter transported through the wetland. A high density of plants provides a greater surface area for screening the other processes related to mechanical separation. A high plant density also enhances the processes of sedimentation, ion exchange, and algal and bacterial growth necessary for organic degradation of particulate matter. Each plant provides a substrate for microrganisms and metazoans, greatly increasing the proportion of water surface area for biochemical activity to occur

2) Areal and Waste Loading Relationships

For a wetland to be of any significant water purification value, it must be large enough to provide sufficient surface area to allow mechanical screening, sedimentation and biochemical degradation processes to proceed towards completion. An optimal ratio of aerated water surface area to total wetland size is also necessary to promote phytoplankton growth which greatly enhances nutrient recycling and oxidation. Too small a water surface area tends to inhibit aeration, while too great an area retards the natural processes of assimilation and bio-geochemical recycling.

Areal relations are important in estimating the potential waste loading tolerance for a particular wetland. However, no empirical information exists to specifically demonstrate a relationship between wetland size and waste loading potential. It seems reasonable to assume that the greater the area of the wetland, the more efficient is the system in terms of waste load assimilation, all other conditions being equal. Numerous studies are presently being conducted to determine the relative rates at which various types of wetlands recycle organic and inorganic waste products.

As natural purification centers, wetlands are somewhat comparable to faculative stabilization lagoons in waste treatment plants. When one takes a conservative view of typical stabilization lagoon design and operating criteria (refer to Eckenfelder, 1970), it appears reasonable to suggest that an evenly distributed loading of 25 lbs. BOD/acre/day would represent a maximum assimilative limit for a wetland without detracting from otherwise acknowledged values, such as natural biological productivity or habitat. It must be emphasized that this figure is a very rough approximation and it may be expected to vary both within given wetland areas and between wetlands located in different geographic areas.

3) Geographic and Other Locational Factors

Two geographic factors which may be useful in assessing the significance of the water purification function of a wetland are its latitude and position with respect to a known source of pollution.

Mean annual temperature, a function of latitude, is an important rate-determining factor in nearly all aerobic and anaerobic degradation processes associated with natural water purification. In general, the rates at which most chemical reactions occur increase exponentially with rising temperature; commonly, a 10° C increase can double or triple the rate of nearly all chemical reactions, including biological phenomena.

Thus, the relative significance of the water purification function of wetlands directly increases with either the number of frost-free days as a measure of the average temperature range, or with an increase in solar radiation. Ice formation in a wetland inhibits even the mechanical, primary treatment function of plant screening and particulate sedimentation. As the viscosity of water doubles from 30° C to 0° C, a greater amount of material also remains suspended in colder water. Furthermore, undecomposed organic wastes which accumulate in wetlands during cold periods tend to create heavy benthic oxygen demands during spring months, thus limiting the effectiveness of the water purification process.

The location of a wetland relative to a source of known pollution discharge is also important in determining its water purification value. Specific problems of either point or non-point pollution sources which may be somewhat mitigated by the presence of wetlands downstream include:

a) sedimentation;
b) organic matter and nutrients;
c) pesticides;
d) salinity, irrigation return flows;
e) heavy metals, radionuclides;
f) urban runoff;
g) livestock pollutants;
h) infiltrates of terrestrial waste products;
i) background emissions, air pollution, other particulate matter; and
j) industrial toxic wastes.

Accumulations of toxic pollutants (heavy metals, pesticides and radionuclides) in streams and wetlands are primarily linked to natural sedimentation processes. The areas of sedimentation are sinks which are capable of concentrating many, if not all, of the non-biodegradable pollutants. Studies have indicated that sediments and aquatic plants

many times possess concentrations of non-biodegradable substances over three orders of magnitude higher than the mean concentrations in overlying waters.

If there are a large number of industries disposing toxic by-products into a particular watershed or coastal zone, the associated wetlands could be acting as long-term storage areas for potentially dangerous industrial wastes. Although wetlands of this type are functioning as water purification centers in the strictest sense, the operation may have minimal, or even negative, connotations in terms of the other known functions and/or wetland values. Similar conclusions must be drawn about those wetlands which receive fertilizers or pesticides transported from large agricultural areas. Recognition and identification of such pollutant inputs should be incorporated into the evaluation of wetlands as recycling areas.

Evaluation

Evaluation of the relative importance of a particular wetland with respect to water quality improvement involves consideration of the type of wetland, its areal relation and specific locational factors. These criteria can be easily measured using available topographic, vegetation and climactic maps in order to make broad generalizations about the particular wetland in question. It may be necessary to subdivide these categories into more refined measures and criteria depending on the local data availability through the application of both inductive and deductive methods.

Assessment of the water quality improvement function of a wetland also involves a high degree of professional judgment on the part of the evaluator. It must be emphasized that scientific knowledge of this particular function is still minimal; therefore, special caution must be exercised in estimating organic waste loading tolerances for individual wetlands. Since pollutant recycling is a major function of many types of wetlands, the evaluator must also be aware of the cumulative effects that pollutants could have on the overall integrity of the wetland system, especially in terms of the otherwise acknowledged natural functions and cultural values.

The matrix on the following page is suggested to provide a preliminary estimate of the natural water purification function of wetlands:

Evaluative Factors	Criteria	Value
A. Wetland Type		
1) Hydroperiod	Semi-diurnal intertidal	High (3)
	Perennial riverine	High (3)
	Irregularly flooded intertidal	Moderate (2)
	Permanently flooded lacustrine	Moderate (2)
	Intermittently flooded riverine	Low (1)
	Intermittently flooded lacustrine or palustrine	Low (1)
2) Vegetation Density	Dense (coverage greater than 80 percent)	High (3)
	Moderate (coverage 50-80 percent)	Moderate (2)
	Open (coverage 20-50 percent)	Low (1)
B. Areal and Waste Loading Relationships		
1) Total Wetland Size	Greater than 100 acres	High (3)
	10-100 acres	Moderate (2)
	1-10 acres	Low (1)
2) Proportion of Water Surface Area to Wetland Area (acres, hectares)	40-60 percent	High (3)
	60-75 percent	Moderate (2)
	Greater than 75 percent	Low (1)
3) Proportion of tidal inlet, river channel or bay water volume flowing through wetland or overland run-off retained in the system (cfs, mgd)	Greater than 50 percent	High (3)
	25-50 percent	Moderate (2)
	Less than 25 percent	Low (1)
4) 5-day BOD loading (lbs. BOD/acre/day)	5-15 lbs	High (3)
	15-25 lbs	Moderate (2)
	Greater than 25 lbs	Low (1)

C. Geographic and Other Locational Factors

1) Frost-free days	Greater than 250 days 175-250 days Less than 175 days	High (3) Moderate (2) Low (1)
2 Location with reference to known pollution sources	Below known source of municipal waste discharge	High (3)
	Above known water intakes	High (3)
	Below area of non-point source pollution	Moderate (2)
	Below known industrial waste discharges	Low (1)

2.9 Cultural Values

Description

Up to this point emphasis has been given to basic evaluation of the known biological and physical functions which characterize wetland ecosystems. However, many wetland areas also exhibit important socio-economic and/or unique cultural values which merit recognition in any systematic environmental evaluation. Many of the socio-economic benefits associated with wetland habitats, such as commercial fisheries or other basically renewable resources, may be significant in terms of national, regional or local economic development. Cultural considerations, including recreation, aesthetics or other special values, are also important because they represent social perceptions primarily based on an intrinsic appreciation for the natural environment. However, these characteristics are far more difficult to evaluate than are those dealing strictly with economic development, and may vary with time as social perceptions change or evolve.

The wetland values, either economic or culturally perceived, are manifestations of the biological and physical functional relations. Analyses of these values can serve to confirm or further reinforce the evaluation of wetlands based on the natural characteristics. Since a detailed discussion of the socio-economic and cultural values of wetland ecosystems is beyond the scope of this document, only a brief consideration of these factors will be presented here. However, it should be emphasized that, in certain instances, perceived socio-economic or cultural values could have a far greater import in the evaluation of wetlands than would the inherent biological and physical functions.

1) Socio-economic Benefits

The major socio-economic benefits which directly pertain to wetlands are commercial fisheries and renewable resources and agriculture.

a. Commercial Fisheries - Many of the important commercial fishery resources in the United States are closely linked with wetland ecosystems, particularly those in or adjacent to marine or estuarine environments. Total catch for the 12 most important economic fish species by weight and value are shown in Table 2-8. These statistics indicate that of the top four species landed by weight, three are estuarine dependent; and of the top four species by economic value, three are also estuarine dependent. As previously indicated in Section 2.2, estuarine wetlands do provide essential habitat for numerous fish and crustaceans. Many economic species, such as the sessile oyster, may spend their entire life

cycle within the estuarine environment, while others, especially oceanic species, are dependent on estuarine wetlands for spawning, feeding, cover and nursery for their progeny.

Table 2-8. Total U.S. Commercial Fisheries Catch Statistics (1973)

Ranking by Weight			Ranking by Value		
Rank	Species	Million Pounds	Rank	Species	Million Dollars
1	*Menhaden	1900.0	1	*Shrimp	220.4
2	*Shrimp	379.7	2	*Salmon	127.6
3	Tuna	346.6	3	Tuna	91.4
4	*Crabs	297.4	4	*Crabs	87.7
5	Anchovies	277.7	5	*Menhaden	75.1
6	Groundfish	259.3	6	Lobster	53.7
7	*Salmon	221.6	7	*Oysters	39.0
8	*Flounders	168.9	8	*Clams	34.7
9	*Clams	107.5	9	*Flounder	33.0
10	Sea herring	102.5	10	Groundfish	29.8
11	*Alewives	59.8	11	Halibut	18.8
12	*Oysters	51.9	12	*Scallops	8.0

*Denotes estuarine dependence

In the New England and North Atlantic region, commercial fishing is an older economic preoccupation than in any other coastal area in the United States, and much of this is for estuarine dependent or associated species. Chesapeake Bay, one of the largest estuarine systems in this region, is also one of the richest fishing grounds on the East Coast. Wetlands within this area provide essential habitat for numerous fish of economic importance, especially the menhaden and oyster.

Other estuarine areas noted for their commercial fisheries are the Gulf of Mexico and the South Atlantic region. The Gulf area is regarded as one of the most diverse fishing grounds in the United States as more than 60 species of fish and 20 species of invertebrates are harvested from these waters. The fishing grounds from the South Atlantic region are in many respects similar to those of the Gulf of Mexico. Commercial fauna here are composed of both semitropical and temperate species, including shrimp, oysters and crabs.

Large commercial fish industries are also developed in riverine and lacustrine environments. Important harvests of commerical species are taken from the Great Lakes and the Mississippi River system. Wetlands along the Great Lakes are mainly limited to river mouths, but these areas are essential for spawning, nursery and resting, and cover habitats for a variety of fish species. Similarly, species of commercial importance utilize the wetland areas of the Mississippi system for habitat during all or part of their life cycles. Wetland dependent, commercial fish industries are also developed along the Northwest region of the United States. The large salmon grounds present along the Alaskan coast are due to the extensive river and lake systems and associated wetland areas. Halibut, shrimp and crab also constitute important fishing resources in this area. Along the lower Northwest Coast (Washington to central California), the river and lake systems are less extensive, but the estuarine areas are still important habitat for salmon, oysters and clams.

b. Renewable Resources and Agriculture - From prehistoric times, inland and coastal wetlands have provided the source of natural food, fiber and fur products. Initially, natural products were important to the subsistence ways of life of the American Indians and the Nation's first European setlers, but many of the goods and commodities have become economically important and are still exploited on a large scale.

Wetland areas, especially coastal marshes, are extensively utilized for livestock grazing, especially cattle, hogs and to some extent, horses. Salt hay (*Spartina patens*) was a major source of stock food in the original colonies and along the Gulf Coast. These natural wetland pastures are still of economic importance in local areas, although large-scale grazing tends to be limited by mosquitos and the lack of firm ground support for livestock.

Peat and sphagnum are harvested from bogs in the glaciated areas in the Northeast and Midwest for both agricultural and garden use. Wild cranberries, a highly specialized and labor intensive crop, are also harvested from bogs in Maine, Massachusetts, Washington and Wisconsin. Broadleaf arrowhead tubers are harvested in wetlands along the Upper Mississippi River for use in the American Chinese food trade. Wildrice is also an important commodity grown in wetlands and constitutes a locally important grain product in many areas of the United States.

Many wetland areas support economically important populations of fur bearers. Palmisano (1972) notes that muskrats lead all other North American wild fur bearers, both in terms of numbers caught and overall pelt value. Approximately 50 percent of all muskrat pelts produced in the United States now come from the northern Gulf marshes of Louisiana and Mississippi. Other wetland dependent-fur bearers of economic importance include the mink, racoon, otter, bobcat, opossum and beaver.

Timber harvests have long been associated with wetlands, especially those in riverine swamps and other freshwater systems. Many of the commerically important forests of New England, the Great Lake states and the Pacific Northwest are found in wetland areas. The Mississippi bottom lands and backwater areas, the southern overflow forests of the Atlantic Coastal Plain and the Big Thicket in Texas are examples of the economically important, southern riverine and palustrine forest systems which are commercially exploited for lumber and other wood products.

Cypress along the Atlantic Coastal Plain is in high demand and has been subject to much selective cutting. White cedar is still harvested for posts and poles in the freshwater swamps and bogs in the North and Northeast, although this once valuable resource has been greatly over-exploited and reduced in economic importance.

2) Culturally Perceived Values

The main culturally perceived values associated with wetlands pertain to recreation activities, aesthetics and other special values.

a. Recreation - Recreation is a vital personal and social need which provides opportunity for self expression, physical exercise and a change of pace from normal or routine activities. Outdoor recreation is a major leisure activity and is growing in national importance with the advent of the shorter work week and a trend towards a higher standard of living.

A significant portion of the total recreational output is water-based or water-related. The nation's coastal areas, lakes and rivers have traditionally been a magnet to those in pursuit of recreational opportunities. Water has always been the medium for a variety of athletic sports; it attracts the fisherman, the sightseer and those who wish to study nature. Water-related activities tend to draw people

together, but at the same time, the spatial qualities of water areas serve to insulate and provide the opportunity for privacy and solitude.

Wetlands can be an important part of this outdoor water-based scenario, but can also function independently as unique, natural recreational areas. Noted areas where wetlands form the dominant landscape feature associated with national recreation include the Great Dismal Swamp, the Okeefenokee Wilderness and the Everglades National Park. On a much smaller scale, it must also be recognized that there are numerous wetland areas across the United States which provide recreational activities for regional or local populations. These wetlands can provide various recreational activities which often include: sport fishing, hunting, recreational trapping, camping, picnicking, hiking, nature study and observation, photography, painting and horseback riding.

b. Aesthetics - Wetlands are also distinctive landscape features which can please the aesthetic sense through the intrinsic appreciation of natural beauty. Wetlands, or any other type of natural landscape, can also be offensive if their features have been adversely modified by incompatible human activites. For many Americans, the scene of a marsh fringing a natural pond can generate an impression of beauty which cannot be totally captured by description, painting or photography. If such a scene is transformed to include the smell of petroleum wastes, smoke from burning refuge, trash and rusted car bodies, the former impression of beauty can quickly turn to one of sheer ugliness.

These opposing scenarios suggest two fundamentally different means to evaluate aesthetic appreciation of wetland landscapes. In the first, aesthetic value is largely determined by the degree of visual diversity and contrast between the physical elements (landforms, water bodies, vegetation types, land use types, etc., (Smardon, 1973). Jones and Jones (1974) use the terms "intactness," "vividness," and "unity" to determine and describe the aesthetic qualities of a particular landscape. Intactness refers to the freedom from encroachment, intrusion and eyesores that result from human abuse of natural conditions. Vividness refers to the visual impression that one receives from the landscape, which closely relates to the elements of diversity and contrast presented by Smardon. Unity refers to the degree which individual elements in the landscape combine to form a single coherent and harmonious visual unit.

The methods of evaluation used by these workers require the analysis of natural and abstract characteristics. The evaluation of these criteria uses a "positive" analytical approach which requires an indepth understanding of the landscape and implied social values; an approach which would be difficult, if not impossible, to routinely implement at the operative level in most Corps of Engineers regulatory evaluation and planning activities.

A second basic approach to aesthetic evaluation, requiring much less knowledge in landscape principles, involves analyses of "negative" elements of the landscape. This method relies on the identification and evaluation of more objective, tangible aesthetic characteristics by providing penalties for eyesores and other negative elements of the landscape. This kind of approach is considered more appropriate in this case as the "positive" landscape features and their aesthetic implications are taken into account in the evaluation of other wetland functions and values.

The approach used in this document for the evaluation of aesthetic characteristics of wetlands assumes that all such environments in their natural state have high value. Evaluation of these characteristics is then based on the degree to which the negative elements or influences affect the overall perception of the wetland. Some of these negative criteria include the following considerations:

a) Adverse Air Quality
b) Adverse Water Quality
c) Adverse Noise
d) Nonconforming Uses

Air quality has a maximum aesthetic appeal when it is free from pollutants, low in humidity and relatively low in velocity. Air pollution originating from a wetland or an adjacent area may contain offensive or obnoxious odors, may be irritable to the skin and possibly the eyes. The emission of unnatural fumes, gasses, water vapor or suspended particulate matter over the wetland could create a negative aesthetic effect by rendering the landscape dull, flat or even by obscuring its visibility.

Aesthetic appreciation of a wetland is directly related to the visual evidence of water pollution. Excessive quantities of stagnant water, floating debris, and the presence of dyes, scum, oil or other unnatural substances tend to have a negative effect on the aesthetic value of a wetland. In addition to man-induced pollutants, many wetlands by virtue of their poor drainage are reducing environments and emit odors as a result of natural biological processes. If extreme and persistent in occurence, these natural odors may be regarded as offensive and have a negative effect on the aesthetic appreciation of the particular wetland.

High noise levels which clash with the tranquility of nature are thought to be unnatural and detract from the perception of landscape beauty. Continuous high noise levels in wetlands adjacent to freeways, industrial complexes and airports would tend to create adverse or negative impressions about the particular environment.

The visual integrity of a wetland area is also determined by the harmony which exists between the natural setting and the intrusive activities of man. A wetland can be extensively used by man and still retain most of its aesthetic appeal, provided that the land use does not conflict with

the basic natural setting. A nature trail with signs explaining vegetation or wildlife relations would be an example of a conforming use of a wetland. On the other hand, a garish billboard standing above and detracting from the wetland setting would not. Junked cars, garbage dumps and associated litter and trash are other examples of nonconforming uses that negatively affect the quality of the wetland vista.

c. Historical and Archeological Importance - Special values associated with wetlands pertain directly to their cultural importance as historical and/or archeological sites, and their unique or unusual physical and biological characteristics.

Since the early 1900's, various Federal laws have been specifically concerned with the preservation of the nation's historical and archeological resources, many of which occur in or adjacent to wetland areas. Brief review of the important legislation concerning historical and archeological preservation is presented below.

The Antiquities Act of 1906 marked the beginning of cultural resources preservation and management by the Federal Government. This Act empowered the President to designate national monuments of historic, or scientific interest and provided for their management.

The Historic Sites Act of 1935 (P.L. 74-292) expanded the cultural resources program and made it a national policy to preserve historic sites, buildings, and objects of national significance for public use. The law provided for the establishment of programs designed for preservation of historical and archaeological resources through investigations and research administered by the National Park Service under the guidance of the Secretary of the Interior. Resulting programs of this law include the Historic American Buildings Survey, the Historic American Engineer Register, the National Landmarks and the National Historic Sites.

The National Historic Preservation Act of 1966 (P.L. 89-665) established the National Register of Historic Places. The register is a listing of cultural resources considered to be of local, state, regional or national importance including all National Landmarks. The Advisory Council on Historic Preservation, created by the Act, administers a national program of grants for preservation work and is responsible for: (1) advising the President and Congress about preservation matters, (2) encouraging preservation in private areas, (3) recommending studies concerning preservation activities, (4) advising state and local governments, and (5) encouraging training and education in historic preservation. It is also concerned with issues that bring progress and preservation into conflict. Specifically, the planning for any Federal or Federally-supported undertaking including licensing actions, which may have an effect upon properties listed on the National Register. When an adverse effect is determined, the Advisory Council must be given an opportunity to comment.

Section 101(b) (4) of the National Environmental Policy Act further declares that an important objective of the national environmental policy is to "preserve important historic, cultural, and natural aspects of our national heritage, and maintain, whenever possible, an environment which supports diversity and variety of individual choice."

Executive Order 11593 (1971) directed the Federal Government to provide leadership in preserving the nation's cultural and historic environment and to assure that Federal plans contribute to the preservation of non-Federally owned sites, structures, and objects of historical, architectural, or archaeological significance.

Pursuant to these national policies and program, it is incumbent upon the Corps of Engineers to specifically consider needs and potentials pertaining to cultural and historical resources in its regulatory program as well as in the planning and implementation of its own water resource development projects.

In evaluating the possibility that a wetland has historical or archaelogical significance, the National Register of Historic Places is the primary source of information.

The National Register of Historic Places is compiled and updated by the National Park Service, Department of the Interior. As properties, sites, or objects become eligible for listing in the National Register, notification appears in the Federal Register. The National Park Service annually publishes an updated version of the National Register which appears in the Federal Register in February of each year.

A second source of information on historic and archaeological aspects is coordination with the State Historic Preservation Officers responsible for the State activities under the National Historic Preservation Act. These officers compile inventories of sites of state or regional importance, have information on sites for which nomination to the National Register may be pending, and can supply the name of the local or county historical society which may have additional historic data.

Inclusion of sites on the National Register of Historic Places provides a level of protection from destruction or encroachment. The historic and/or archaeological resources which are represented must be specifically taken into consideration during the planning and implementation of any Federally sponsored, Federally supported, or Federally regulated projects or programs. Inclusion on the National Register does not directly affect or restrict the ownership status of the sites or areas involved. The same can be said about places of local or state significance. As many sites with known historical or archaeological importance carry little more than a certification from local or state historic societies and conservation interests.

d. Special Values

In addition to historical or archeological importance, many wetlands contain unusual flora or fauna, unique ecological or geological characteristics or other naturally occurring phenomena which impart a special consideration to the environment. Some wetlands support or provide habitat for rare, restricted or relic flora or fauna. A rare species is defined as one only found in a few locations within a geographical area, while a restricted species is only found in certain specialized habitats. A relic species is one surviving from an ancient lineage and has an extremely limited distribution, isolated from its normal area of habitats.

Other wetlands may provide habitat for fauna or flora at or near the periphery of their range. Wetlands such as these present unique educational or research opportunities to study the environmental factors which affect the survival and limit the distribution of the particular species. In addition to these considerations, there may be instances where wetlands are relatively limited in a given area which in itself merits recognition and imparts a special meaning to their preservation.

Evaluation

Because of the numerous variables and subjective characteristics involved in the analysis of socio-economic and cultural values of wetlands, the assesent of these criteria is largely left to the professional judgment of the local evaluator. Socio-economic benefits derived from a particular wetland area may be generally assessed in terms of the commerical value of the commodity, the associated number of employees and their level of wages, related land values or the number of tourists using the wetland and their market area. These criteria are by no means inclusive, and each wetland should be evaluated at the local, regional and national level to determine its own relative importance with regard to any proposed project modification.

The culturally perceived values of recreation, aesthetics and other special considerations which may characterize certain wetlands are equally difficult to assess. Other than those values recognized by law (historical and archeological sites; rare, endangered or relic species), cultural perspectives of wetlands vary considerably and must by necessity be analyzed on an individual, site-specific basis. Again, the evaluator is urged to assess each individual cultural factor relevent to the wetland in question and make the appropriate decisions by indepth, local assessment of the resource.

Chapter 3
METHODS OF EVALUATION

3.1 Introduction

The purpose of this chapter is to describe various methods for wetlands evaluation using basic concepts developed in earlier sections and to demonstrate their application in hypothetical wetland situations. These methods are intended for use by personnel in Corps of Engineers field offices to aid in the evaluation of proposed permit activities and civil works projects which involve wetland areas.

The baseline evaluation of wetlands is necessary where physical changes are anticipated which might bear directly or indirectly on the continued function of the wetland as an ecological unit, or where such changes might impinge on known or suspected cultural values. It may also be necessary to determine the relative value of one wetland in relation to another in order to analyze and rank site alternatives as a basis to select less sensitive or less valuable sites for developmental purposes. From the program perspective, the evaluation of wetlands is desirable in order to assess the relative importance of wetlands within broader geographic areas for planning and management purposes.

3.2 Objectives

In order for a wetlands evaluation method to have operational utility within the Corps of Engineers it should be capable of: structuring a rational thought process, standardizing analytical approaches to evaluation, and providing for the proper documentation of findings and conclusions. Importantly, it should also permit the application of experience and the expression of individual and local preferences. These objectives can lead to the systematic, orderly development of ideas with the characteristic of replicability, and permit the reexamination of the resultant evaluation at some future date.

A useful method of evaluation should contain a balance of the following characteristics:

(1) Simplicity-

(a) usable by personnel with only moderate experience in wetlands evaluation,

(b) requiring only moderate quantities of information,

(c) requiring moderate resources and time;

(2) Reliability - possess a high likelihood of producing values ultimately useful in judging relative worth;

(3) Accuracy - produce values reflecting comparative worth;

(4) Comprehensiveness - include all possible characteristics which might reflect upon the ultimate worth;

(5) Transferability - be useful in both a specific and generic sense, across temporal and spatial lines.

(6) Flexibility - be capable of adjusting to varying degrees of technical difficulty as well as varying operational priorities. Ideally, an evaluation method should be capable of being targeted to specific problems to permit the case by case balancing of available time and resources against the quality of the resultant evaluation.

3.3 Suggested Approaches

The two approaches to wetlands evaluation suggested here are believed to adhere to the above objectives and characteristics. Both involve use of deductive reasoning, based on inferences from accepted principles, for wetlands evaluation and decision making. The more complex of the two approaches involves the development and comparison of numerical ratings after value judgments are made. One method is termed deductive analysis and the second, comparative analysis.

Deductive Analysis. This is intended as a non-quantitative approach and is based on a systematic evaluation of the degree to which the wetlands under examination satisfy each of the functional characteristics and cultural values. It is suggested that a non-quantitative summary of the conclusions and reasons for these conclusions be included as an integral part of the method. The deductive analysis is best adapted to and is therefore recommended for use in the piecemeal baseline evaluation of wetlands in situations where normally no site alternatives are presented. Its utility would appear to be greatest in the Corps' permit program.

Comparative Analysis. This method is intended as a quantitative analysis and involves the systematic evaluation of the degree or efficiency with which two or more wetland areas under study satisfy criteria pertaining to functional characteristics and cultural values. The quantitatively ranked comparison of wetland values and functions makes it possible to assess the relative environmental importance of site alternatives for proposed water resource development projects.

3.4 Procedural Considerations

Study Area Delineation.

The size and configuration of the study area in wetlands evaluation will in actuality vary according to the specific wetland function or value under analysis. For example, the study area involved in the analysis of

ecological processes, particularly those involving the delivery of energy to downstream systems, would normally be large and perhaps linear in shape. For the analysis of the flood water storage or groundwater recharge functions, the study area would most likely encompass an entire drainage basin, or at least that portion of a watershed lying topographically or geologically below the wetland area under investigation. At the other extreme, a study area of much more restricted size might be involved in the analysis of the shoreline protection function and many of the cultural values. Size and configuration of study area should be a preliminary determination in wetlands evaluation because of the strong influence these characteristics have on data requirements and basic study approach.

Information Requirements. Wetlands evaluation will necessitate the analysis of data and information which is specific to the various functional characteristics and values. State agencies which have wetlands management and regulatory responsibilities are prime sources of information as to wetland values. Academic institutions with wetlands curricula are also dependable sources of essential information. However, the evaluator will not always have all the required information readily available, nor will he have it in a form which allows for its direct use. In these situaions, the evaluator will often be faced with the necessity to engage in more laborious effects entailing the collection and analysis of data and information on a more piecemeal basis. Important inferences concerning certain of the wetland functions and values are possible simply through the interpretation of basic topographic, hydrologic, cultural, land cover and land use information which is contained on readily available maps, charts and aerial photographs. These constitute essential tools in wetlands evaluation.

Documentation. The official record of wetland evaluation is a matter of primary concern whether applying to the civil works or regulatory programs. The official record should contain the results of the deductive or comparative analysis along with an explanation of the rationale leading to the conclusions. In addition, the report on an evaluation should document for the record the background data and information which is used in making all the various analyses.

The manner in which background information is documented should vary according to scale or importance of the project involved and be a matter of local discretion. In the case of large or controversial projects, reason dictates that the documentation of background information should be detailed and complete, perhaps in anticipation of its ultimate use in an environmental impact statement (EIS). An example of a more detailed narrative style of documentation is shown in the following section under "Analysis of a Hypothetical Wetland." The other extreme would be small and non-controversial projects for which background information might consist of little more than a locally developed checklist or matrix of wetland characteristics.

The degree of detail provided in the reporting of actual evaluation results would also tend to vary from project to project. The only general rule which is presented in this regard is that the format used and level of detail should trace a logical path to the judgements made by the evaluator. Tables 3-2 and 3-3 in the hypothetical wetlands analysis are generalized report formats suggested for use in recording results of the deductive and comparative analyses.

The forms may be altered to satisfy the user, but in their present configuration, Table 3-2 is intended to document findings in narrative fashion using deductive analysis while Table 3-3 contains spaces in the upper righthand corner for rating and comparing numerical values developed during comparative analysis (reproducible blank copies of Tables 3-2 and 3-3 as well as the Habitat Evaluation Checklist are contained in the Appendix to this manual).

Since deductive analysis deals with wetland values non-quantitatively, the final step in this analysis is a summary and conclusion as to how well the wetland in question is deemed to fit the evaluation criteria. The comparative analysis on the other hand permits the derivation of overall numerical expressions of value or importance for site alternatives through summation of the ratings assigned to individual functions and cultural values. The numerical sum is not considered to be an exact quantitative measure of wetland value; it therefore should not be used to compare or rate contrasting wetland systems beyond the instant analysis. However, the numerical sums can be used reliably as indicators of relative value for site alternatives in planning or permit review situations within a given wetland area.

3.5 Analysis of a Hypothetical Wetland

This section illustrates the quality and quantity of information necessary for a typical evaluation using the suggested methods and report formats. It shows how the information is used for (1) evaluation of a given wetland area by means of deductive analysis, and (2) comparative analysis of two locations in the wetland system for the purpose of determining the most appropriate location for a proposed project.

DEDUCTIVE ANALYSIS

Background Information

The wetland area is located in Worcester County, Maryland, 5 kilometers south of Maryland Route 309, and 7.5 km due south of Marshville (Fig. 3-1). It is on a coastal embayment of Chincoteague Bay near the entrance of Teal Creek to the Bay. Teal Creek is a small tidal inlet with an area of approximately 0.9 sq. km. draining towards the bay and the ocean.

Worcester County covers a total of 586 sq. mi. of which 482 sq. mi. is land and 104 sq. mi. is water. The resident county population is 102,000; the population within 1 mi. is zero; and the population within 10 mi. is 246. Structures on the wetland consist of two abandoned duck-blinds; an abandoned barn within 3 mi; two service stations within 3 mi; and the town of Marshville, some 4.6 mi distant, consisting of 13 residences and 2 commercial establishments.

Point source discharges to this wetlands are unknown since the town of Marshville is served by individual septic systems and no local industry exists. Non-point source discharges consist of about 75 acres of agricultural land used primarily for cultivation of row crops, such as corn, and for some small timber harvest.

This wetlands has not been given any local, state or national recognition as a unique area or historical place. Although the area has been surveyed by state resource agencies, no special study status has been designated.

Physical Characteristics. The area is in the temperate zone with an average annual temperature range from 20^{o} F to 97^{o} F and an average annual precipitation of 41.3 inches for the years 1950-1977. Prevailing winds are northwesterly with the usual strong seabreeze in the evenings of the warmer months. The area has an average of 265 frost-free days.

Geologically, the wetland lies on the subaerial and submarine portion of the Coastal Plain Province. The entire peninsula consists of a wedge-shaped mass of sediments, up to nearly 8000 feet in thickness, overlying crystalline rocks of Pre-Cambrian and Paleozoic age. Sedimentary rocks consist of sands, greensands, gravels, silts, clays, shales, and shell beds correlated with the Triassic, Cretaceous, Tertiary and Quaternary Systems.

The elevation ranges from 1.5 to 3.4 feet at mean datum sea level and the topography is flat to gently rolling. A sandy barrier island 1 mile wide lies 4.5 mi. east of the wetland area. Soils are generally sandy with heavy organic accumulations away from the edges of the Bay and tidal streams.

Important water bearing strata are found in the Pleistocene Series, which are up to 230 feet thick below the wetlands. Extraction from this series can produce over 5,000 gpd (gallons per day) of water relatively low in dissolved solids but slightly "irony" in flavor. Test wells drilled into the Tertiary sediments have yielded over 25,000 gpd and these formations have storage capacity considered to exceed 50 million acre feet.

The total wetlands system is 4600 feet long and 2300 feet wide, encompassing some 239 acres. Teal Creek divides the area exactly in half and the subject wetland is therefore about 120 acres. The ratio of the size of wetland under study to the size of the adjacent water body

(defined as the area extending to ordinary high water to the barrier islands) is about 1 to 20. The hydrologic linkage of the wetlands to the adjacent water body is direct through tidal inundation and the drainage of Teal Creek.

The distances to the next closest wetlands are: 800 feet north to a wetland system of 68 acres and 1 mile south to a wetland system of 342 acres. Since the separation between the three consists of headlands and dunes, the linkage between the three is indirect through the tidal route.

Bay currents east of the wetlands are variable with wind and tide but are normally a net 0.5 knot flow south southwesterly; the tidal moment is 1.5 feet to 2 feet. The salinity ranges from 29.5 to 32 parts per thousand at the bayside, depending upon season and precipitation. There is no beach; at low tide the water lies below a broken, vegetated edge. The bottom slope is easterly, between 3 and 5 percent across the entire embayment. Wave heights are usually less than 2.5 feet except during easterly storms when waves may approach 5 feet. Fetch during a northeaster is 4.5 miles.

Inundation of up to 60 percent of the total wetlands occurs during the normal tidal excursion but during spring tides up to 90 percent of the wetlands is covered. When spring tides are concurrent with easterly storms, the entire wetlands area may be under water; at the bayside, water levels may approach the tops of the emergent grasses.

Biological Characteristics.

The wetland is located in the lowland ecoregion of the Southeastern Mixed Forest Province (Bailey, 1976). The wetland is classified in the Estuarine System, subclass Persistent Emergent Wetland, and is typical of sheltered euhaline embayments of the Atlantic and Gulf Coasts of the United States (Cowardin et al., 1977). The wetland vegetation is characterized by abundant stands of saltmarsh cordgrass, and the adjacent dry land community is a willow-oak-loblolly pine association. The aquatic community is typical of high salinity rooted aquatics.

The dominant terrestrial plant species (in numbers) in this wetlands area are: saltmarsh cordgrass (Spartina alterniflora), saltmeadow cordgrass (Spartina patens), saltgrass (Distichlis spicata), hightide bush (Iva frutescens), and at a far fifth, Olney three-square (Scirpus olneyi). The dominant aquatic plant species (in numbers) are eelgrass (Zostera marina), widgeongrass (Ruppia maritima), horned pondweed (Zannichelia palustris), and sago pondweed (Potamogeton pectinatis).

Areal coverage by dominant vegetation is about 95 percent, with the following rank orders estimated: saltmarsh cordgrass - 70 percent; saltmeadow cordgrass - 13 percent; saltgrass - 10 percent; hightide bush - 5 percent; and Olney three-square - 2 percent. Aquatic vegetation extends to about the 3 foot depth interval with no good estimates of

rank order except that eelgrass appears to comprise over 50 percent of the coverage. Productivity of saltmarsh cordgrass and saltmeadow cordgrass is acknowledged to be among the highest of all natural systems.

The terrestrial animal population is a typical marshland community and the aquatic animal community is a high salinity, estuarine-type. The dominant terrestrial animal species (in numbers) are the plant hopper (*Prokelisia marginata*), the marsh periwinkle (*Littorina irrorata*), the saltmarsh mosquito (*Aedes solicitans*), the grasshopper (*Orchelium fidicinium*), and several species of greenhead flies of the family Chloropodidae. The dominant aquatic animal species (in number) are the clamworm (*Neanthes succinea*), the mummichog (*Fundulus heteroclitus*), the banded killifish (*Fundulus majalis*), the variegated minnow (*Cyprinidon variegatus*), and the hard shell clam (*Mercenaria mercenaria*).

The trophic structure of the ecosystem is considered simple within each stratum. For example, saltmarsh cordgrass dominates at the waters edge due to its tolerance for salt and moisture and effectively excludes its competitors. However, there are numerous "strata of tolerance" from the 1 m depth interval to dry land and at each level, different species dominate. Therefore, taken as a whole, this wetland comprises a complex trophic structure of numerous habitat types. This same explanation can be used to describe conditions of diversity. As individual habitat units, these strata contain relatively few species but large numbers of those few species--a characteristic of highly eutrophic systems. However, the diversity of organisms when viewed across the entire wetland system is high.

Numerous other animals utilize this wetland at various stages of their life cycles, the most significant being those of recreational, aesthetic and commerical value. Following is a list of species considered to be significant in this respect.

Game and Commercial Fish Species

bluefish
white perch
striped bass
Norfolk spot
hardhead
spotted seatrout
winter and summer flounder
menhaden

Waterfowl

blackduck
mallard
blue-winged teal
canvasback
redheads
Canada geese
whistling swam
brant
eider

Forage Fishes

killifish
mummichog
anchovies
silverside
young menhaden

Wading and Shorebirds

clapper rail
King rail
great blue heron
green heron
black-crowned night heron

American egret

American bittern
dowitcher
curlew
golden plover and numerous sandpipers

Songbirds

grackle
catbird
yellow-throat
marsh wren
red-winged blackbirds
song sparrow

white-throated sparrow
grasshopper sparrows and numerous warblers in season

Mammals

least weasel
muskrat
mink
red fox
raccoon
swamp rat
meadow vole
deer mice
jumping mice
least shrew and an occassional white-tailed deer

Amphibians

bullfrog
pickerel frog
green frog
spring peepers
tiger salamander

Reptiles

water snake
diamond-backed terrapin
mud turtle
soft-shelled turtle

Crustaceans

fiddler crab
hermit crab
blue crab
mud crab
grass shrimp
mud shrimp

Molluscs

American oyster
soft-shelled clams
razor clams
hardshell clams
the angel wing

The attempt here has been to acknowledge relatively common species which at some stage of their existence use this wetlands for: year-round living, resting, nesting, spawning, feeding or wintering. Some species may have been left out because they do not meet these criteria.

Economically, there are no plant species in this wetland having a local market value in and of themselves. Marketable animals include many of the game and commerical species mentioned above, especially the muskrat, the American oyster and the hardshell clam.

No resident endangered or threatened plant or animal species are known in this hypothetical wetlands. Some sea turtles (occasional visitors) and some avifauna which rest in and on the fringes of this wetlands during migration may be endangered or threatened.

Table 3-2 which follows illustrates the method for deductive analysis of the functions and values derived from this hypothetical wetland, and demonstrates the scope of coverage, level of detail and format necessary for documentation of results.

TABLE 3-2 IDENTIFICATION AND ANALYSIS OF WETLAND FUNCTIONS AND VALUES (DEDUCTIVE ANALYSIS)

FUNCTIONAL CHARACTERISTICS
NATURAL BIOLOGICAL FUNCTIONS *Food Chain Production* 1. *Net Primary Productivity - Presumed high due to known value of dense stands of Spartina alterniflora.* 2. *Mode of Detrital Transport - Presumed highest possible value due to direct linkage with adjacent waters and intertidal circulation.* 3. *Food Chain Support - Presumed high due to total biomass produced, complexity of trophic structure and to high biological diversity.*
Generalized and specialized habitat *This characteristic evaluated primarily by completion of Habitat Evaluation Checklist.* *The wetland is ascribed a high value primarily because of:* 1. *Year-round association of forage fishes,* 2. *Spawning and nurturing of game and commercial fin fish and shell fish.* 3. *The location of this wetland on a primary flight path for migrating avifauna with seasonal occurance of key species.* *(See attached habitat evaluation checklist.)*

HABITAT EVALUATION CHECKLIST
(Key game, commercial and aesthetic species)

Fish and Wildlife Species	Habitat Significance High (3)	Mod. (2)	Low (1)	Remarks
Oysters	X			Commercially Important
Hardshell Clam	X			Commercially Important
Muskrat		X		Moderately Abundant. Not Commercially Important.
Clapper Rail		X		Local Recreational Importance
Diamond-backed Terrapin		X		Abundant, But Not Commercially Important
Snow Geese and Canada Geese		X		Discretionary Resting and Feeding Habitat
Whistling Swan			X	An Occasional Winter Visitor
Puddle Ducks		X		Discretionary Resting and Feeding Habitat
Stripped Bass	X			Nursery and Feeding Habitat
Winter and Summer Flounder	X			Nursery and Feeding Habitat
Menhaden	X			Nursery and Feeding Habitat
Spotted Sea Trout	X			Nursery and Feeding Habitat
Spot and Croaker		X		Spawning and Nursery Habitat
Blue Crab		X		
Overall Habitat Value				A Diverse and Productive Wetland Habitat

TABLE 3-2, Continued

FUNCTIONAL CHARACTERISTICS
AQUATIC STUDY AREAS, SANCTUARIES OR REFUGES *This area is not used for scientific study purposes and does not serve as a sanctuary or refuge. It possesses no unique natural characteristics which might qualify the area for listing on the National Registry of Natural Areas - Low*
HYDROLOGIC SUPPORT FUNCTION 1. *Hydrologic Periodicity - estuarine - High* 2. *Location or Elevation Within Wetland System - Low to mean water level - High*
SHORELINE PROTECTION 1. *Vegetation Characteristics* A. *Type of wetland vegetation - intertidal marsh grasses* B. *Density of vegetation community - Dense (>80%)* 2. *Areal Extent - Width of wetland perpendicular to shore - more than 200 yds - High* 3. *Fetch < 4.5 mi - Moderate* 4. *Cultural Development - No significant infrastructure within 2 miles.*

TABLE 3-2, Continued

FUNCTIONAL CHARACTERISTICS
STORAGE FOR STORM AND FLOOD WATERS N/A
NATURAL GROUNDWATER RECHARGE N/A

TABLE 3-2, Continued

FUNCTIONAL CHARACTERISTICS

WATER PURIFICATION THROUGH NATURAL WATER FILTRATION

1. *Wetland Type*
   - A. Hydroperiod - both high and low intertidal marshes included - moderately high
   - B. Vegetation density - High

2. *Areal Relations*
   - A. Total Area - High
   - B. Proportion of Open Water - 20 to 1 - Low
   - C. Proportion of total water volume flowing through system - Moderate
   - D. 5-Day BCD loading - Low

3. *Geographic and Other Locational Factors*
   - A. Frost free period - Moderate
   - B. Area not strategically located with respect to waste sources or water supply intakes.

Potentially the area could serve a highly effective role in waste removal; however, the lack of water quality problems in this lightly populated locality on Chincoteaque Bay make this an academic consideration. On balance the wetland area's current water purification function is of moderate value.

CULTURAL VALUES

COMMERCIAL FISHERIES

Contributes to growth and sustenance of a large number of organisms of high economic importance (oysters, clams, menhaden, blue fish, hardhead, etc.)

TABLE 3-2, Continued

CULTURAL VALUES
RENEWABLE RESOURCES AND AGRICULTURE *No known agricultural products; no trapping of fur bearers; only infrequent harvesting of diamond-back terrapins, but this activity is insignificant to local economy - Low*
RECREATION *State and local use only limited.*

TABLE 3-2, Continued

CULTURAL VALUES
AESTHETICS *No negative influences.*
HISTORICAL OR ARCHEOLOGICAL IMPORTANCE *N/A*

TABLE 3-2, Continued

CULTURAL VALUES
HABITAT FOR RARE, RESTRICTED OR RELIC FLORA OR FAUNA *N/A*
OTHER CONSIDERATIONS *Serves as overflow and feeding area for avifauna (including ibis and cattle egrets) from summer rookeries in the adjacent areas.*

TABLE 3-2, Continued

CULTURAL VALUES
SUMMARY AND CONCLUSIONS *This wetland is considered valuable because:* *1. It is relatively pristine and isolated.* *2. It provides essential habitat for extensive game and commercial fish species.* *3. It harbors and nurtures extensive coastal avifauna, mammals, reptiles and amphibia.* *4. It is important to the contiguous coastal ecosystem as an area of high food chain production.* *(A somewhat lower value may be ascribed due to lack of capability for shoreline protection, storage, recharge and water purification.)*

COMPARATIVE ANALYSIS

The comparative analysis is conducted at two locations within the hypothetical wetland area in response to a proposed project for which there exist two site alternatives. The purpose of the comparative-type analysis is to determine the relative value of the alternative locations as an input to decision making. For the most part, physical and biological conditions specified for both locations are essentially the same. The differences between them which are relevant to a proposed project are cited below under their appropriate categories. In order to place these differences in context, the proposed change is also briefly summarized below. Reference should be made to Figure 3-1 in this analysis.

Identification of the Alternative Project Locations. The Worchester County government proposes certain tax benefits and limited public investment to encourage construction of a marina on the shores of Chincoteague Bay to make the area more attractive to tourists and fishermen. The proposed marina will consist of a tackle-bait-snack building, finger piers for mooring 100 boats, a boat launching ramp, parking for 200 cars, a picnic grove, and an all-weather road linking the area to State Route 432. Two locations are proposed: Location A, and about .6 mi. north, Location B. Some physical aspects of these two locations are:

(1) Location A - The required access road is 1650 feet long and is considered relatively easy to maintain. There is practically unlimited space for possible future expansion and Location A is considered more attractive than B from an aesthetic viewpoint. Location A has the disadvantage of requiring a lengthy dredged channel to straighten Teal Creek and arrive at the edge of marsh, but funding is available from the State Department of Economic Development to defray dredging costs. Also, the long channel is considered advantageous for protection from storm tides.

(2) Location B - This area is located further into the marsh than is A, and the access road to the facility will be approximately 2500 feet long. The road will require construction of two 300 foot bridges and a large volume of fill will be needed for its completion. The access road will also be subject to periodic flooding. The proposed dredged channel is much shorter, but is less protected from storm tides than that of Location A.

Table 3-3 which follows demonstrates the method for comparative analysis of the site alternatives and illustrates the scope of coverage, level of detail and suggested report format.

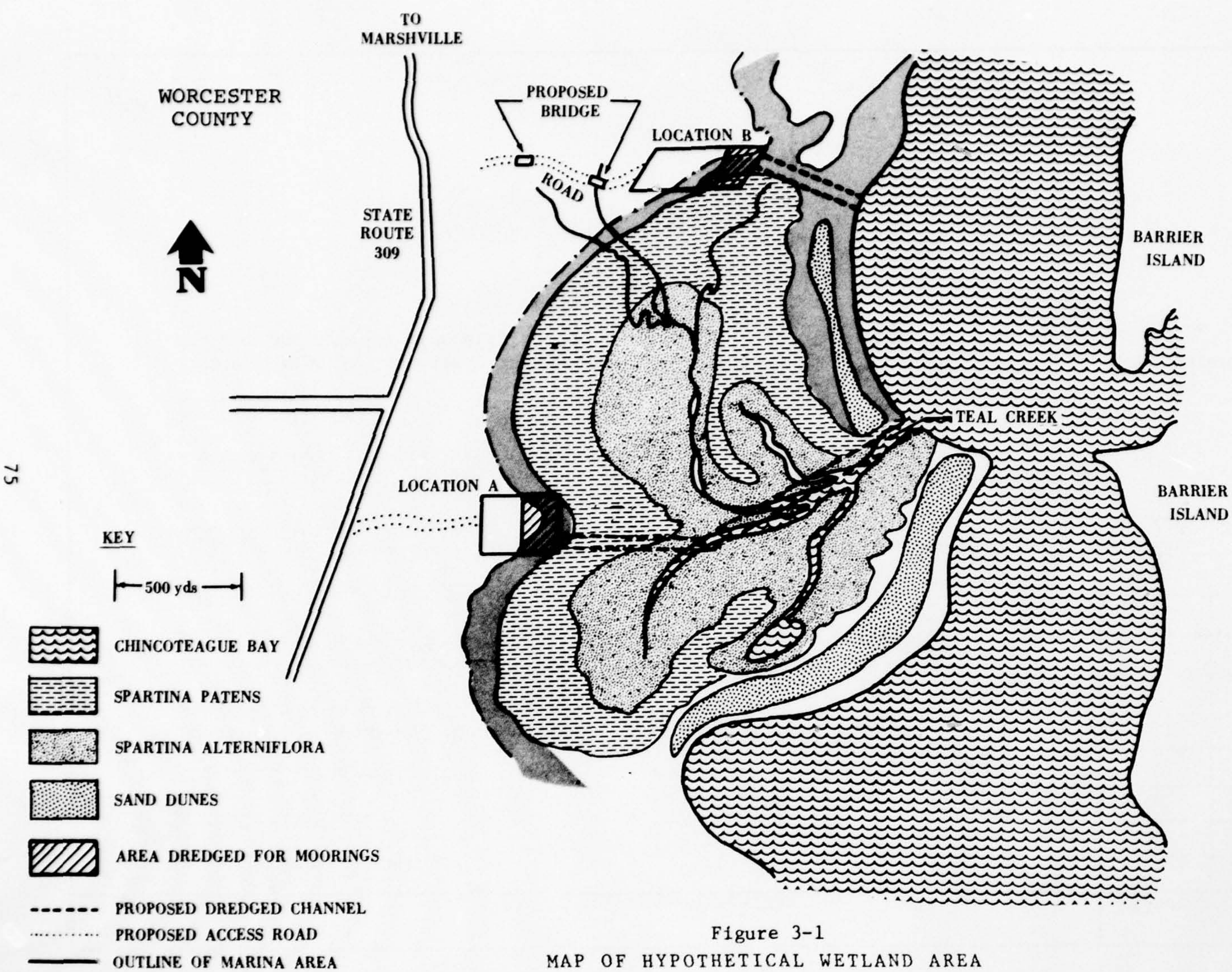


Figure 3-1
MAP OF HYPOTHETICAL WETLAND AREA

TABLE 3-3 COMPARATIVE ANALYSIS OF SITE ALTERNATIVES

FUNCTIONAL CHARACTERISTICS

NATURAL BIOLOGICAL FUNCTIONS

Food Chain Production

1. *Net Primary Productivity*

   Location A - About 80% dense stands of S. alterniflora (some patens) Productivity very high.

   Location B - Small amount of S. alterniflora, major proportion S. patens, with high productivity but somewhat less than at Location A.

2. *Mode of Detrital Transport*

   Location A - Direct tidal linkage with adjacent waters, rapid exchange facilitated by Teal Creek.

   Location B - Tidal linkage less direct - blocked from bay except during extreme tides. Limited exchange through upper extremes of Teal Creek.

3. *Food Chain Support*

   Presumed high in both areas as evidenced by overall community trophic structure, high system biomass and species diversity.

Alternatives

	A	B	
1.	3	2	
2.	3	2	
3.	3	3	
$\tilde{X}$	3	2.3	

TABLE 3-3, Continued

FUNTIONAL CHARACTERISTICS	Alternatives			
NATURAL BIOLOGICAL FUNCTIONS		A	B	
General and Specialized Habitat		3	2	
Location A - More rapid exchange of greater volumes of water due to location at the lower end of the wetland and influence of Teal Creek, plus slightly higher productivity cause total habitat and habitat support to be higher than Location B. Refer to Habitat Evaluation Checklist (see following)				
Location B - Location higher in the wetlands, less frequent tidal inundation, less standing water, somewhat lower productivity, cause habitat and habitat support to be somewhat lower in value than Location A. Refer to Habitat Evaluation Checklist. Still meets criteria for moderate habitat value.				

TABLE 3-3, CONTINUED

FUNCTIONAL CHARACTERISTICS	Alternatives			
AQUATIC STUDY AREAS, SANCTUARIES OR REFUGES		*n/a*	*n/a*	
Neither location is under private or public administration; neither possesses unique natural characteristics, neither known to be formally used for scientific study and neither considered eligible for listing in National Registry of Natural Landmarks.				

HABITAT EVALUATION CHECKLIST
(Key game, commercial and aesthetic species)

Fish and Wildlife Species	Habitat Significance High (3)	Mod. (2)	Low (1)	Remarks
Oysters	A		B	
Hardshell Clam	A		B	
Muskrat		B	A	
Clapper Rail	A		B	
Diamond-backed Terrapin		B	A	
Snow Geese and Canada Geese		AB		
Whistling Swan			AB	
Puddle Ducks		A	B	
Stripped Bass	A		B	
Winter and Summer Flounder	A		B	
Menhaden	A		B	
Spotted Sea Trout	A		B	
Spot and Croaker		A	B	
Blue Crab	A		B	
Overall Habitat Value	A	B		

TABLE 3-3, Continued

FUNCTIONAL CHARACTERISTICS	*Alternatives*			
HYDROLOGIC SUPPORT FUNCTION		*A*	*B*	
1. *Hydrologic Periodicity* - Both estuarine - High.	1.	3	3	
2. *Location or Elevation Within Wetland System* -	2.	3	2	
Location A - Low in system - Frequency of inundation high.				
Location B - High in system - Frequency of inundation moderate.				
	$\tilde{X}$	3.0	2.5	

TABLE 3-3, Continued

FUNCTIONAL CHARACTERISTICS	Alternatives			
		A	B	
SHORELINE PROTECTION 1. Vegetation Characteristics a. Type of Wetland Vegetation Location A - Intertidal marsh grass - Moderate - 2 Location B - Intertidal marsh grass - Moderate - 2 b. Density of Vegetation Community Location A - Dense (>80%) - 3. Location B - Dense (>80%) - 3. 2. Areal Extent Location A - Width perpendicular to shore - 200 yd - High - 3. Location B - Not directly at shoreline except during extreme tides - Low - 1. 3. Fetch Location A - < 4.5 mi - Moderate - 2. Location B - Barely applicable - 1. Cultural Development No significant infrastructure within 2 mi of either location.	1.	2.5	2.5	
	2.	3	1	
	3.	2	1	
	$\tilde{X}$	2.5	1.5	

TABLE 3-3, Continued

FUNCTIONAL CHARACTERISTICS	Alternatives			
		A	B	
STORAGE FOR STORM AND FLOOD WATERS				
N/A		*n/a*	*n/a*	

TABLE 3-3, Continued

FUNCTIONAL CHARACTERISTICS	*Alternatives*			
		A	*B*	
NATURAL GROUNDWATER RECHARGE *Neither area presumed to serve role in groundwater recharge due to their intertidal location - N/A.*		*n/a*	*n/a*	

TABLE 3-3, Continued

FUNCTIONAL CHARACTERISTICS

WATER PURIFICATION THROUGH NATURAL WATER FILTRATION

1. *Wetland Type*

   A. *Hydroperiod - both locations intertidal although Location B high marsh - A-high-3; B-moderate-2*

   B. *Vegetation density high at both locations - 3 & 3*

2. *Areal Relations*

   A. *Total wetland size - both locations 1-10 acres - low - 1 & 1*

   B. *Proportion of open water low at both locations - 1 & 1*

   C. *Proportion of water volume flowing through system low at both locations - 1 & 1*

3. *Waste Loading Potential (5 day BOD Loading) - low at both locations - 1 & 1*

4. *Geographic and Other Locational Factors*

   A. *Frost free days 175-250 - moderate - 2 & 2*

   B. *Neither location strategically located with respect to waste discharge or water intakes- 1 & 1*

Alternatives	A	B
1a.	3	2
1b.	3	3
2a.	1	1
2b.	1	1
2c.	1	1
3	1	1
4a.	2	2
4b.	1	1
$\tilde{X}$	1.6	1.5

TABLE 3-3, Continued

CULTURAL VALUES	Alternatives			
		A	B	
RENEWABLE RESOURCES AND AGRICULTURE *Little potential at either location. Harvest of Diamond-back terrapins by local residents at both locations, but not significant to local economy. - Low (1)*		1	1	

TABLE 3-3, Continued

CULTURAL VALUES	Alternatives			
RECREATION		A	B	
Only limited state and local use at both locations.		1	1	

TABLE 3-3, Continued

CULTURAL VALUES	Alternatives			
		A	B	
AESTHETICS		3	3	
No negative influences at either location.				

TABLE 3-3, Continued

CULTURAL VALUES	Alternatives			
HISTORICAL AND ARCHAEOLOGICAL IMPORTANCE		A	B	
N/A		n/a	n/a	

TABLE 3-3, Continued

CULTURAL VALUES	Alternatives			
<u>HABITAT FOR RARE, RESTRICTED OR RELIC FLORA OR FAUNA</u>		*A*	*B*	
N/A		*n/a*	*n/a*	

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TABLE 3-3, Continued

CULTURAL VALUES	*Alternatives*			
		A	*B*	
OTHER CONSIDERATIONS		3	2	
Both locations serve as overflow and feeding area for unusual avifauna from summer breeding colonies on islands in Chincoteague Bay.				
Location A - Probably has slightly higher value due to more extensive inundation, greater quantities of standing water.				

TABLE 3-3, Continued

TOTAL VALUES, SUMMARY AND CONCLUSIONS	Alternatives			
		A	B	
Both locations A and B indicate a strong organic, as opposed to physico-chemical contribution to the adjacent lands and waters. The higher evaluation ascribed to site A is indicative of the slightly lower topographic aspect of that site, its correspondingly greater hydrologic linkage with adjacent water and wetland areas, higher rate of productivity and higher biomass. It should also be emphasized that construction of the marina at site A requires extensive excavation with potential disruption of a natural tidal creek. Despite the economic advantage which site A seems to present, this analysis suggests that there is an offsetting environmental argument for locating the marina at site B.		46.5	37.5	

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APPENDIX

IDENTIFICATION AND ANALYSIS OF WETLAND FUNCTIONS AND VALUES (DEDUCTIVE ANALYSIS)

FUNCTIONAL CHARACTERISTICS

IDENTIFICATION AND ANALYSIS OF WETLAND FUNCTIONS AND VALUES (DEDUCTIVE ANALYSIS)

CULTURAL VALUES

COMPARATIVE ANALYSIS OF SITE ALTERNATIVES

FUNCTIONAL CHARACTERISTICS	*Alternatives*			

COMPARATIVE ANALYSIS OF SITE ALTERNATIVES

CULTURAL VALUES	*Alternatives*			

HABITAT EVALUATION CHECKLIST
(Key game, commercial and aesthetic species)

Fish and Wildlife Species	Habitat Significance			Remarks
	High (3)	Mod. (2)	Low (1)	
Overall Habitat Value				

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